AMATEUR RADIO

How and Why of Wireless with Complete Instructions on Operation of Receiving Outfits

By

Maurice J. Grainger

Radio Expert, formerly with The Westinghouse Electric and Mfg Co. and the United States Navy

World Radio History

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With over 150 Diagrams and Illustrations

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The author wishes to acknowledge his indebtedness to the Radio Corporation of America and the Ship Owners' Radio Service for much valuable material which has been incorporated in this book. He also desires to put on record his thanks to J. Herbert Duckworth for editorial advice and assistance.

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INTRODUCTION

THIS book has been compiled especially for the amateur owner of a radiophone receiver who knows little, or nothing, about why and how his instrument works. Many of those who have acquired radio sets are not satisfied with simply turning knobs, finding sensitive spots on crystals, regulating the amount of incandescence in their vacuum tubes, and then sitting calmly back to enjoy the broadcasted programs.

They have become fascinated by the romance of radio; they want to learn something of the inner workings of this new and wonderful scientific toy; they want explained to them in language that even a layman may understand, something of the mysteries of this seemingly most inexplicable and uncanny of contraptions that even a child can operate. Such words as "dielectrics," "series multiple-circuits," "heterodyne" and "rheostats" frankly puzzle him. He wants made as plain to him as the action of a typewriter, or camera,

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just why sounds sent out from a broadcasting station many miles away can be picked up with a jumble of wire, crystals and electric bulbs.

It is to satisfy the curiosity—reasonable and commendable curiosity—of this large and growing class of radio enthusiasts that this work has been put together. In reality there are few subjects that can be so readily understood as "wireless." To the "old-timers" and the real "ham" of the wireless game, and to others who have made a study of matters electrical this book is not primarily addressed. But even the amateur who has been through the hard but interesting school of practical experimentation—the school that started before the war with the "plain aerial spark transmitter," will, I think, find many things of value between these covers.

To those whose knowledge of things electrical is, to say the least, very scant, but who will never be satisfied until they can conscientiously tell themselves that they at least comprehend the fundamental principles upon which this most marvellous of inventions is based, this book is particularly and respectfully dedicated.

THE AUTHOR.

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CHAPTER I

RADIO WAVES

How Speech is Carried Without Wires—What Wave-Length Is—Speed of Radio Waves

How does a radiophone work? How is speech carried without wires? How do numberless receiving sets pick up the messages or music from the same broadcasting station? Questions like these puzzle many people who have only recently, through the radiophone, become interested in matters electrical.

By the use of a little analogy I will try to make clear just how the human voice and music are sent radiating out into the night air and are picked up from places at all points of the compass.

Imagine that a small pebble has been thrown into a big pond. Tiny ripples commence to circle out from the point of contact. Next a good sized brick has been cast into the water. Instead of ripples miniature waves are set rolling in ever-widening circles.

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Perhaps the wavelets, both the big ones and the smaller fellows, meet a reed or some other obstacle sticking out of the water. Where the ripples hit the obstruction they are momentarily bent. But they proceed on their way just the same.

Now you can liken the missive thrown into the water to the transmitter. The sticks showing above the surface of the water are the receiving stations. The rock is like the powerful broadcaster; the pebble a small station. (See Fig. 1.)

Tall buildings, trees and other obstructions, absorb some of the power of the ether waves just as obstructions met with on the surface of the pond weaken, to some extent, the force of the water waves that strike them.

Radio waves are like these commotions set up on the surface of a pond. Just as the water waves are so many inches apart so are the ether waves. Ether waves are measured in meters. When you say that the wave is 360 meters long you mean that measured from crest to crest the wave is that many meters in length.

But while waves set up on a lake will gradually die out until they completely disappear, the scientists have a theory that ether waves

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Fig. 1
Principle of wave transmission pictorially shown. A. Transmitting station. B and C Receiving stations.

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never cease to exist when they are once set in motion. They go on travelling into space for ever. Were there receivers sensitive enough to detect them they would be picked up thousands of years after they had been set free and trillions of miles away from the transmitter, for ether waves move at the rate of 186,000 miles a second.

Now let me attempt to visualize for the reader just how these "wave-lengths" are utilized in the operation of wireless telegraphy and telephony. I am indebted to the Ship Owners' Radio Service, Inc., for the following exceedingly clear and interesting explanation of how the different wave-lengths are prevented from interfering with each other:

We might compare four radio transmitting stations to four singers on a single stage. As long as the quartet sang together everything would be fine. But suppose that the tenor sang "Home Sweet Home," the soprano, "Bubbles," the basso, "Annie Laurie" and the contralto, "The Star Spangled Banner" all at the same time. The result would be what, in radio parlance, is referred to as "interference."

Now suppose that you had in your pocket a little device that, when placed against your ears and properly adjusted, would exclude the

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basso, contralto, and tenor voices, but would allow the soprano voice to pass. The result would be that you would hear only the clear soprano strains of "Bubbles," unmarred by the bedlam of "Annie Laurie," "Home Sweet Home," and "The Star Spangled Banner." You would simply turn the knob on your little device so that it would exclude the basso, tenor, and soprano, but pass the contralto voice, and you would hear your favorite song, undisturbed by the soprano "Bubbles," or any other.

If the singers were compared to radio stations, and you called the basso voice a "200-meter wave length," the tenor a "600-meter wave length," the contralto a "360-meter wave length," and the soprano a "1200-meter wave length," and your little pocket device you compared to a radio receiver, the analogy would be complete.

In order that a number of radio stations in the same vicinity may transmit signals at the same time, and not interfere with one another, one will transmit on a 200-meter wave length, another on 360 meters, another on 600 meters, another on 1200 meters, and so on. In order that a radio receiving station may listen to any station at will, the receiving instrument is provided with one or more adjusting knobs

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or switches, so that the "wave-length" of the receiver may be adjusted to correspond with the wave-length of the station it is desired to hear. This process is known as "tuning."

The wave-length range has no direct bearing on the distance over which a sending station may be heard. This depends on the power used by the transmitting station, and the sensitiveness of the receiving instrument, just as in the theatre analogy, a partially deaf man in the front row could not hear as well as the man in the back row who had good hearing. If the partially deaf man went to the back row, he might not hear at all unless the singer fairly shouted. The loudness of the singing would compare with the "power" of a transmitting station, and the degree of deafness would compare with the sensitiveness of a receiver.

To carry the theatre analogy one step farther, suppose that one man in the audience sat directly behind a large pillar. He would probably not hear the singing as well as the man who sat in the open. Tall steel buildings, abrupt hills, etc., obstruct radio signals in a somewhat similar manner, and that is why the amateur who lives among skyscrapers will not get quite as good results as the amateur

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who lives among two or three-story buildings, or, better still, out in the country.

The term "wave-length range," as I have said, has nothing to do with the range in miles. Wave-length is simple to understand. Messages from the transmission stations are sent in the form of waves of electrical energy. The actual length of these waves may vary from 160 to 26,000 meters. To receive a broadcasting station which you know transmits on a wave-length of 360 meters, you simply tune your receiver to 360 meters. You should then receive only that one station. To receive stations sending on a longer or shorter wave-length, adjust your receiver accordingly. Every receiving instrument has a certain wave-length-range, which means that it responds to all wave-lengths within these limits, provided, of course, the transmitting stations are within the range in miles of the receiving apparatus. The different wave-lengths make it possible to send different messages at the same time without undue confusion.

The range in miles depends on the power of the transmitting station, the sensitiveness of the receiver, and local conditions. This makes it impossible to specify the exact range in miles of any particular outfit.

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CHAPTER II

ORIGIN OF WAVES

What Happens at the Transmitter—Remarkable Distances Covered with Small Amount of Energy—Alternating and High Frequency Currents

WHAT sets radio "waves" in motion? A series of vibrations in the ether is set up whenever a flow of electricity takes place. The small particles from which electricity is composed, called electrons, theoretically have a hold on the ether, so to speak, and cause a vibration, or strain, to be set up in the ether whenever a movement of electricity takes place. (See Fig. 2.)

The smallest ether disturbance, even that caused by the flow of current when ringing a bell, sets up ether waves which travel an unknown distance. The real problem is not how transmitting sets may be improved, but how receiving sets may. Ether waves can be projected around the earth with an expenditure of very little energy. At present our trans-

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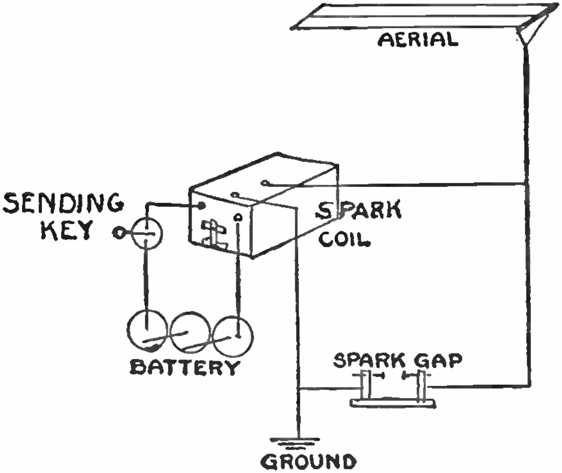

Hook-up of Simplest Type of Transmitting Set.

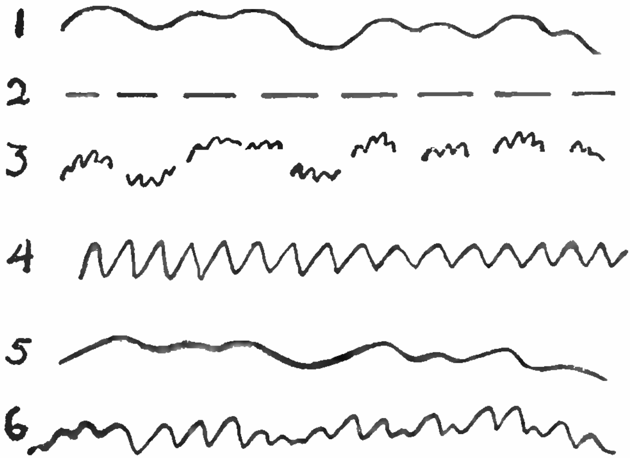

Fig. 2—Wave Curves
(1) Continuous Oscillations. (2) Word Sound Waves. (3) Sound Waves Carried by Oscillations. (4) Continuous Wave Train. (5) Wave Train Carrying Speech. (6) Received Speech.

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oceanic stations use hundreds of kilowatts of power because receiving apparatus will not detect signals if less power be used.

Ether waves, as I have already pointed out, travel at a speed of 186,000 miles a second. This is about 300,000,000 meters per second. Since the speed of ether waves, or vibrations, is nearly the same under all conditions it follows that if we know the wave-length a transmitting station is using we can tell how many waves or vibrations there are per second, or, in other words, the frequency.

The present practical wave-length limits for radio telegraphy and telephony are between 100 meters and 20,000 meters, which represents a frequency range of from about 2,000,000 to 15,000 a second which, of course, would be inaudible, as the normal human ear does not respond to sound waves below forty nor above 10,000 vibrations per second. Therefore radio frequencies, as they are called, cannot be heard.

We must then reduce the radio frequencies to audible or audio frequencies so that they can be heard. This is performed by the detector in the receiving apparatus. This detector changes high frequency radio current

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Frequency and Wave Length Tables

W. L.—Wave Lengths in Meters. F.—Number of Oscillations per Second.
O. or √ L. C. is called Oscillation Constant. C.—Capacity in Micro Farads.
L.—Inductance in Centimeters. 1000 Centimeters = 1 Microhenry.

W.L.	F.	O. or √L.C.	L.C.
50	6,000,000	.839	.7039
100	3,000,000	1.68	2.82
150	2,000,000	2.52	6.35
200	1,500,000	3.36	11.29
250	1,200,000	4.19	17.55
300	1,000,000	5.05	25.30
350	857,100	5.87	34.46
400	750,000	6.71	45.03
450	666,700	7.55	57.00
500	600,000	8.39	70.39
550	545,400	9.23	85.19
600	500,000	10.07	101.41
700	428,600	11.74	137.83
800	375,000	13.42	180.10
900	333,300	15.10	228.01
1000	300,000	16.78	281.57
1100	272,730	18.45	340.40
1200	250,000	20.13	405.20
1300	230,760	21.81	475.70
1400	214,330	23.49	551.80
1500	200,000	25.17	633.50
1600	187,500	26.84	720.40
1700	176,460	28.52	813.40
1800	166,670	30.20	912.00
1900	157,890	31.88	1016.40
2000	150,000	33.55	1125.60
2100	142,850	35.23	1241.20
2200	136,360	36.91	1362.40
2300	130,430	38.59	1489.30
2400	125,000	40.27	1621.80
2500	120,000	41.95	1759.70
2600	115,380	43.62	1902.60
2700	111,110	45.30	2052.00
2800	107,140	46.89	2207.00
2900	103,450	48.66	2366.30
3000	100,000	50.33	2533.20
4000	75,000	67.11	4504.00
5000	60,000	83.89	7033.00
6000	50,000	100.7	10130.00
7000	41,800	117.3	13630.00
8000	37,500	134.1	18000.00
9000	33,300	151.0	22820.00
10000	30,000	167.9	28150.00
11000	27,300	184.8	34150.00
12000	25,000	201.5	40600.00
13000	23,100	218.3	47600.00
14000	21,400	235.0	55200.00
15000	20,000	252.0	63500.00
16000	18,750	269.0	72300.00

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to a pulsating direct current which actuates the telephone receivers.

Ether waves when they strike the aerial are alternating, that is, flow in two directions—strike down to the earth through the antenna and ground connection, and return through the earth to the transmitter, thousands of miles away as is sometimes the case. The next vibration, or wave, flows in the opposite direction—through the earth to the ground connection, up through the receiving set and out of the aerial. These two operations are called a "cycle." The current travels with the speed of light.

As there are many million vibrations per second I will leave it to the reader to imagine how many of these cycles occur in say ten minutes of receiving—or in other words how many billions or trillions of times the current changes its direction during the ten minutes.

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CHAPTER III

MAGNETISM AND ELECTRICITY

Basis of Radio is Magnetism—Phenomena of Magnetic Fields and Induction—Solenoids and Bar Magnets

To understand the operation of radio it is absolutely necessary to be equipped, at least, with a knowledge of the elementary principles of electricity. Let me plunge right into this subject:

If a fragment of hard steel be brought within the influence of a permanent magnet it acquires and retains a certain amount of magnetism. By stroking the magnet with the hard steel the amount of magnetism held is greatly increased. Actually, the steel bar becomes almost as powerful as the magnet from which it obtained its magnetism. The piece of hard steel is then known as a *permanent magnet* also because, unless it is subjected to heating or pounding, it holds its magnetism indefinitely.

When you bring a piece of *soft* iron in close proximity to a permanent magnet it also be-

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comes a magnet and will attract other smaller pieces of iron, but as soon as the permanent magnet is taken away the soft iron loses almost all its magnetism. So soft iron can only form a *temporary magnet.*

If a rod of iron or steel be wound with a number of turns of wire, and a current passed through the wire the rod becomes magnetized, one end being called the north pole and the other the south pole, (See Fig. 3). When the bar is of iron and the current is cut off it loses its magnetism instantly; if it is of steel the rod is made a permanent magnet.

It is known that any wire carrying current has a small magnetic field around it, the magnetic field varying according to the strength of the current. The extent of this magnetic field is shown in Fig. 4.

If the direction of the current in the wire be reversed the direction of the magnetic field is reversed, or, as it is called, the "polarity" is reversed. If the current be passed through the wire from A to B the lines of force around the wire will revolve clockwise, or left to right. If the current be passed through in the opposite direction, from B to A, then the lines of force will flow in the other direction, or counter clockwise. (See Fig. 5.)

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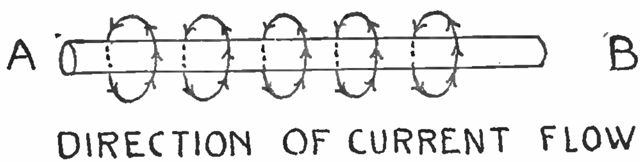

Fig. 3

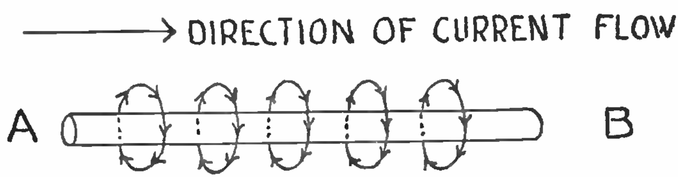

Fig. 4

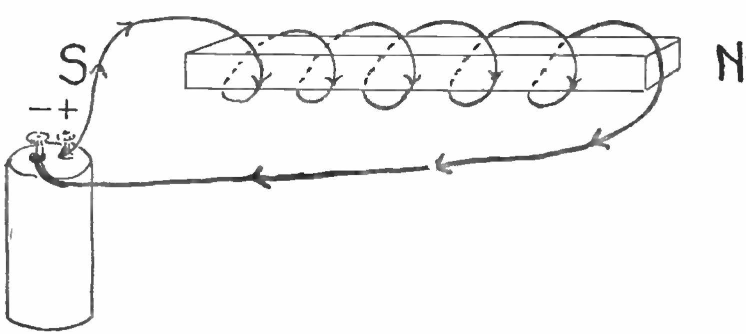

Fig. 5

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In direct current (D.C.) the electricity flows in one direction, and the lines of force move in one direction. In alternating current (A.C.) or in current that changes its direction a certain number of times a second, the lines of force change their direction twice as often per second. If it were a sixty cycle current, then the lines of force would change their direction 120 times, for there are two changes of direction in each cycle.

By winding a copper wire in the shape of a coil and passing a current through it, the coil acquires the properties of a magnet. As copper is non-magnetic it is very easily seen that as soon as the current is shut off the magnetism disappears. This is known as a *solenoid*. By inserting a soft iron core in the hollow of the solenoid the magnetic lines of force, because of the much higher magnetic properties of iron as compared with air, are greatly increased. This also increases what is known as *self-induction*.

If a bar magnet be passed through a coil of wire carrying no current it will put current into the wire. This is *self-induction*. Withdraw the magnet and the current in the wire disappears.

If a coil of wire carrying current be placed

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close to another coil of wire not carrying current it will induce a current in the latter. In all these cases the induced current in the coil is due to the change in the number of lines of magnetic force through the coil.

It is very important that you should know something of magnetism and induction because it will help you to understand the functions of almost every part of your receiver.

For instance, there are the head telephones. You could not understand why the ether waves are made audible in the headpiece unless you had it clear in your mind just what magnetism is.

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CHAPTER IV

HEAD TELEPHONE RECEIVERS

Difference Between Land and Radio Head Telephone Receivers—The "Rating" of Receivers—Ohmic Resistance—Reason for Steel Core Electro-Magnets—Why Mica Diaphragms are Better than Sheet Iron—How to Hook-up Extra Sets of Receivers

THE telephone receiver as used in wireless telegraphy and telephony is practically the same type as that used on land telephone lines, but as they must respond to extremely weak currents they are made with very light diaphragms and are wound with a great many turns of fine wire.

In the telephone receiver are usually two electro-magnets having steel cores, or permanent magnets. These magnets are wound with many turns of fine insulated wire, the effect being a solenoid with a steel core. The reason for the steel core, which may seem to contradict what was written in the last chapter, is that owing to the very small amount of current that comes into the receivers, via the

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aerial, tuner and detector, it is insufficient to make magnets of a soft iron core and move the diaphragm of the receiver. Manufacturers, accordingly, make the cores permanent magnets by making them of steel, thus always exerting a pull on the metal diaphragm, but not enough to pull it to the magnets. (See Fig. 6.)

When the feeble radio current arrives at the telephone all the energy is used in magnifying the attraction that the magnet exerts on the diaphragm. This diaphragm is an exceedingly sensitive piece of the 'phone mechanism. It takes very little energy to move it.

Telephone receivers will not work with alternating current. The current moving in one direction would neutralize the current moving in the opposite direction and there would be no vibration of the diaphragm. Therefore the ether waves, which are alternating currents, must be changed to pulsating direct current. This is done either by means of a crystal or audion detector.

The average beginner regards a pair of receivers as a couple of metallic boxes with hard rubber ear caps. Receivers all look more or less alike, but there is a vast difference on the

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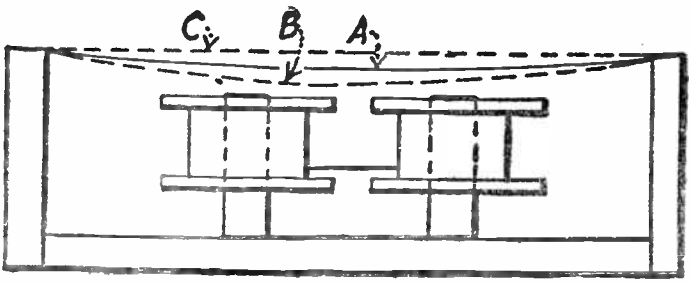

Fig. 6

Fig. 6—Diagram of Telephone Receiver, Showing the Positions of the Diaphragm at Different Stages of Magnetic Saturation. A. Shows Normal Position of the Diaphragm. B. Shows Position of Diaphragm When it is Attracted to the Magnet by the Incoming Signals. C. Shows Position of Diaphragm When it Springs Back at the End of the Oscillation.

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inside. A receiver to really work right should be wound with very fine copper wire, as the whole theory of the radio receiver hinges on the fact that there must be a great many turns of wire very close to an iron core.

While receivers are rated by the resistance that they have, this method of classifying them is entirely wrong. As stated above, the receiver must have these turns of fine wire about the pole pieces of the magnets, and in order to get this a great quantity of wire has to be used. The easiest way to rate the receiver is by the resistance that this wire has, which is really wrong, as the resistance is really a detriment to the 'phones.

The whole idea is to get the number of turns with the least resistance. In order to reduce this resistance a larger size wire may be used, but just as soon as this is done it will be found that owing to the thickness of the wire the distance from the poles will rapidly increase, thereby lowering the efficiency of the receiver.

In order to have a receiver that will give a high ohmic reading or resistance, some manufacturers have gone so far as to wind the receivers with German silver wire. As this

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wire has a high resistance, it will be seen that the receivers will show a high resistance.

This theory is absolutely contrary to correct receiver design, as the receiver has the resistance all right, yet the number of turns is decreased and actually less wire is used. Even the beginner at the game can readily understand that this will make the receiver less efficient, as the high resistance of the 'phone will actually deaden the signals, and, owing to the fact that there are not as many turns, the receiver will be far less efficient.

Another thing in a receiver that may be greatly improved upon is the diaphragm. This is usually a piece of thin sheet iron, and it is the vibrations of iron that are actually heard. While it may do very well for cheap receivers to use this iron diaphragm, the best receivers on the market use a diaphragm of some other material that is more pliable and can be deflected to a greater degree. This will bring the signals in louder, as with the iron diaphragm the magnets have to be placed so close to the diaphragm that they will hit each other and cause the signals to be distorted.

Of course this only happens with very loud signals. With the other type of diaphragm

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some sort of material, such as mica, may be used, and as it is far more flexible it will be found that far greater motion is secured. This is done by attaching a small piece of steel to the mica and the steel is what pulls the diaphragm to the magnets. Thus it will be seen that while steel is still used, the deflection of the mica will give much better results.

It is well to remember that with a pair of 'phones care must be taken not to short circuit the storage battery through them, as the heat generated will cause the fine wire to melt very quickly, and make the receivers worthless because there will not be a complete circuit.

Another thing to avoid is dropping the receivers. This is very apt to break the hard rubber ear-caps, and will also tend to demagnetize the magnets. If a pair of receivers once get in this condition the best thing to do is to throw them away.

Do not attempt to rewind a receiver, as very fine wire is used for this purpose, and it is very apt to be broken while winding, and never be discovered until after all the wire is in place. It is also practically impossible to make a radio receiver out of an ordinary telephone receiver. These receivers are not built right for this sort of work, and the beginner

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is cautioned not to waste time experimenting with them.

Some amateurs desire to use more than one pair of receivers, so that more than one person may listen in at the same time, yet they are puzzled as to how to connect the receivers up. This is very simple, as the sets are connected in series. That is, the end of one receiver cord is connected to the radio set in the usual place, and the other terminal is connected to the terminal of the next pair of receivers, the remaining receiver cord being connected back to the set to the other binding post of the radio set. Any number of receivers may be connected on in this way.

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CHAPTER V

HOW TO MAKE A SIMPLE CRYSTAL SET

(Prepared by U. S. Bureau of Standards)

Essential Parts of a Receiving Station—Antenna, Lightning Switch and Ground Connections

THIS article tells how to construct the entire receiving station, including antenna as well as a crystal-detector receiving set. This station will enable one to hear the messages sent from medium-power transmitting stations within an area about the size of a large city, and to hear high-power stations within fifty miles, provided the waves used by those stations have wave frequencies between 500 and 1500 kilocycles per second (i. e., wave lengths between 600 and 200 meters). Much greater distances are often covered, especially at night. If the amateur constructs the coil and other parts as indicated, the total cost of this set can be kept down to about $6.00. If, however, a specially efficient outfit is desired, the cost may be about $15.00.

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There are five essential parts to a receiving station: the antenna, lightning switch, ground connections, receiving set, and phone. The received signals come into the receiving set through the antenna and ground connection. In the receiving set they are converted into an electric current which produces the sound in the "phone." The phone is either one or a pair of telephone receivers worn on the head of the listener.

The purpose of the lightning switch is to protect the receiving set from damage by lightning. It is used to connect the antenna directly to ground when the receiving station is not being used. When the antenna and the connection to the ground are properly made and the lightning switch is closed, an antenna acts as a lightning rod and is a protection, rather than a source of danger to the building.

The principal part of the station is the "receiving set." In the set here described it is subdivided into two parts, the "tuner" and the "detector," and in more complicated sets still other elements are added.

The antenna is simply a wire suspended between two elevated points. Wherever there are two buildings, or a house and a tree, or two trees with one of them very close to the

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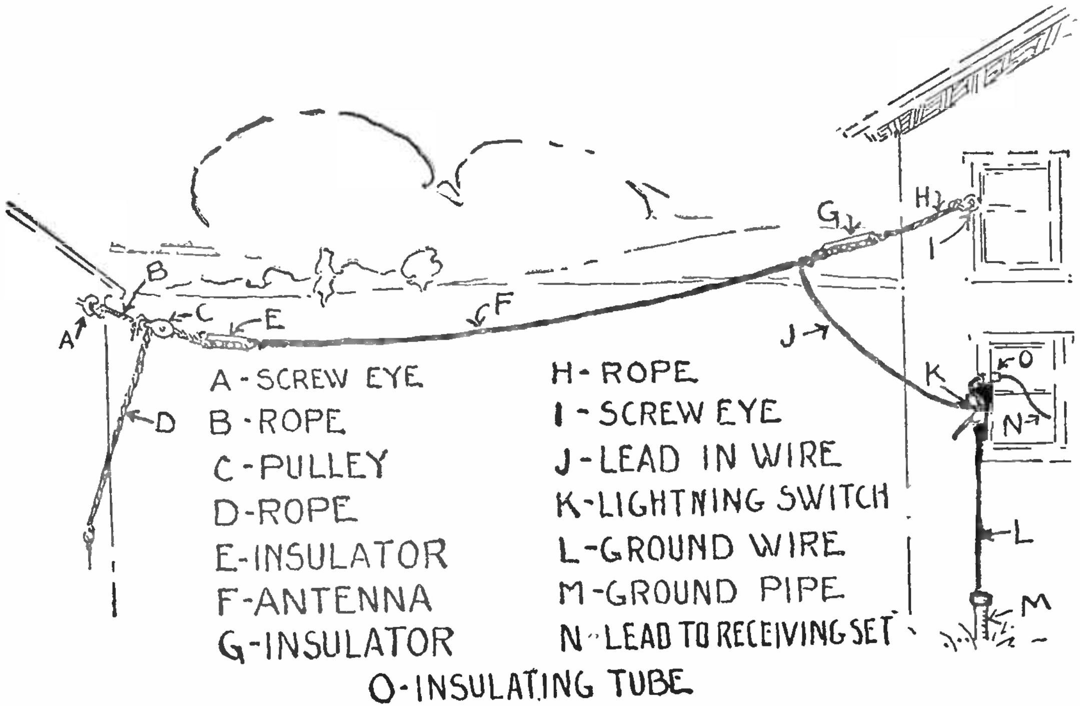

Fig. 7

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house, it relieves one of the need of erecting one or both antenna supports. The antenna should not be less than 30 feet above the ground and its length should be between 75 and 100 feet. (See Fig. 7.) While this figure indicates a horizontal antenna, it is not important that it be strictly horizontal. It is in fact desirable to have the far end as high as possible. The "lead-in" wire or drop-wire from the antenna itself should run as directly as possible to the lightning switch. If the position of the adjoining buildings or trees is such that the distance between them is greater than about 125 feet, the antenna can still be held to a 100 feet distance between the insulators by increasing the length of the piece of rope (D) to which the far end of the antenna is attached. The rope (H) tying the antenna insulator to the house should not be lengthened to overcome this difficulty, because by so doing the antenna "lead-in" or drop-wire (J) would be lengthened.

Details of Parts—The parts will be mentioned here by reference to the letters appearing in Figs. 7, 8, 9.

A and I are screw eyes sufficiently strong to anchor the antenna at the ends.

B and H are pieces of rope ⅜ or ½ inch in

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diameter, just long enough to allow the antenna to swing clear of the two supports.

D is a piece of 3/8 or 1/2 inch rope sufficiently long to make the distance between E and G about 100 feet.

C is a single-block pulley which may be used if readily available.

E and G are two insulators which may be constructed of any dry hard wood of sufficient strength to withstand the strain of the antenna; blocks about 1 1/2 x 2 x 10 inches will serve. The holes should be drilled as shown in Fig. 7 sufficiently far from the ends to give proper strength. If wood is used the insulators should be boiled in paraffin for about 1 hour. If porcelain wiring cleats are available they may be substituted instead of the wood insulators. If any unglazed porcelain is used as insulators, it should be boiled in paraffin the same as the wood. Regular antenna insulators are advertised on the market, but the two improvised types just mentioned will be satisfactory for an amateur receiving antenna.

F is the antenna about 100 feet between the insulators E and G. The wire may be No. 14 or 16 copper wire either bare or insulated. The end of the antenna farthest from the re-

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ceiving set may be secured to the insulator (E) by any satisfactory method, being careful not to kink the wire. Draw the other end of the antenna wire through the other insulator (G) to a point where the two insulators are separated by about 100 feet, twist the *insulator* (G) so as to form an anchor as shown in Fig. 7. The remainder of the antenna wire (J) which now constitutes the "lead-in" or drop-wire should be just long enough to reach the lightning switch.

K is the lightning switch. For the purpose of a small antenna this switch may be the ordinary porcelain-base, 30 ampere, single-pole double-throw battery switch. These switches as ordinarily available, have a porcelain base about 1 by 4 in. The "lead-in" wire (J) is attached to this switch at the middle point. The switch blade should always be thrown to the lower clip when the receiving set is not actually being used and to the upper clip when it is desired to receive signals.

L is the ground wire for the lightning switch; it may be a piece of the same size wire as used in the antenna, of sufficient length to reach from the lower clip of the lightning switch (K) to the clamp on the ground rod (M).

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M is a piece of iron pipe or rod driven 3 to 6 feet into the ground, preferably where the ground is moist, and extending a sufficient distance above the ground in order that the ground clamp may be fastened to it. Scrape the rust or paint from the pipe before driving in the ground.

N is a wire leading from the upper clip of the lightning switch through the porcelain tube (O) to the receiving set binding post marked "antenna."

O is a porcelain tube of sufficient length to reach through the window casing or wall. This tube should be mounted in the casing or wall so that it slopes down toward the outside of the building. This is done to keep the rain from following the tube through the wall to the interior.

Fig. 8 shows the radio receiving set installed in some part of the house.

P is the receiving set which is described in detail below.

N is the wire leading from the "antenna" binding post of the receiving set through the porcelain tube to the upper clip of the lightning switch. This wire, as well as the wire shown by Q, should be insulated and preferably flexible. A piece of ordinary lamp cord

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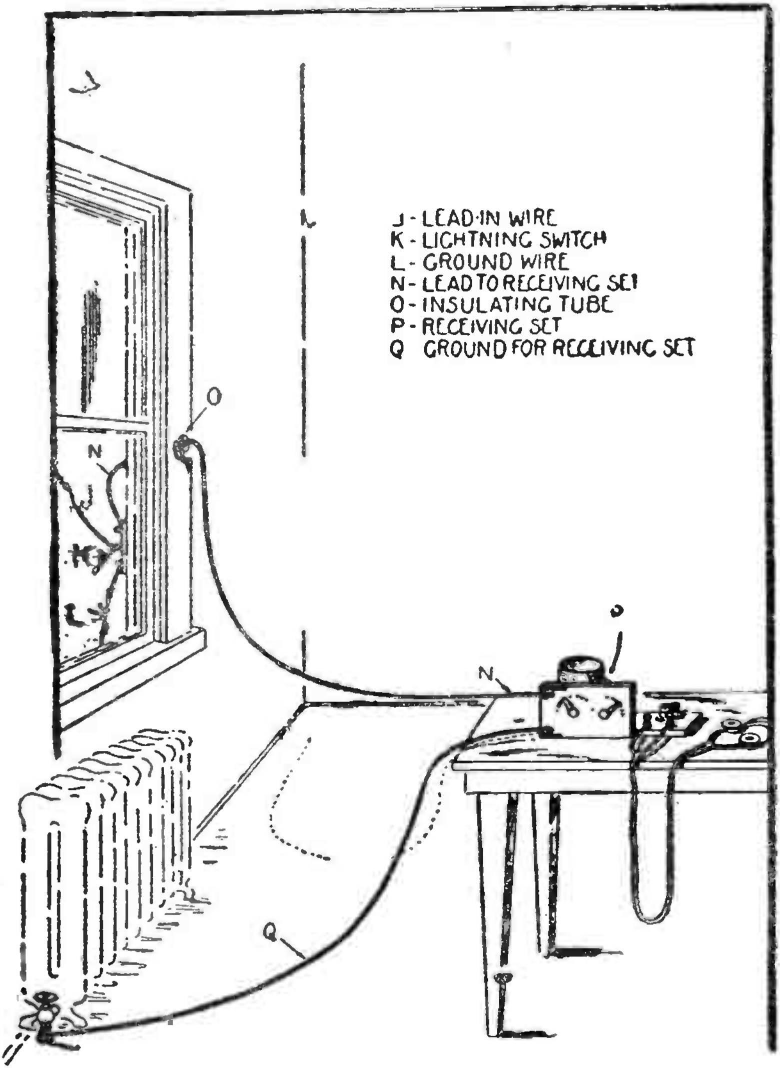

Fig. 8

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might be unbraided and serve for these two leads.

Q is a piece of flexible wire leading from the receiving set binding post marked "ground" to a water pipe, heating system or some other metallic conductor to ground, except M, Fig. 8. If there are no water pipes or radiators in the room in which the receiving set is located, the wire should be run out of doors and connected to a special "ground" below the window, which shall not be the same as the "ground" for the lightning switch. It is essential that for the best operation of the receiving set this "ground" be of the very best type. If the soil near the house is dry it is necessary to drive one or more pipes or rods sufficiently deep to encounter moist earth and connect the ground wire to the pipes or rods. This distance will ordinarily not exceed 6 feet. Where clay soil is encountered this distance may be reduced to 3 feet, while in sandy soil it may be increased to 10 feet. If some other metallic conductor, such as the casing of a drilled well, is not far away from the window, it will be a satisfactory "ground."

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CHAPTER VI

HOME-MADE PARTS FOR CRYSTAL RECEIVER

A Simple Cardboard Tuner—How to Mount Crystals—Some Parts that Can be Improvised

THE detector and phone will have to be purchased. The tuner and certain accessories can be made at home.

Tuner (R, Fig. 9)—This is a piece of cardboard or other non-metallic tubing with turns of copper wire wound around it. The cardboard tubing may be an oatmeal box. Its construction is described in detail below.

Crystal Detector (S, Fig. 9)—The construction of a crystal detector may be of very simple design and quite satisfactory. The crystal, as it is ordinarily purchased, may be unmounted or mounted in a little block of metal. For mechanical reasons the mounted type may be more satisfactory, but that is of no great consequence. It is very important, however, that a very good tested crystal be used. It is probable also that a galena crystal will be more satisfactory to the beginner.

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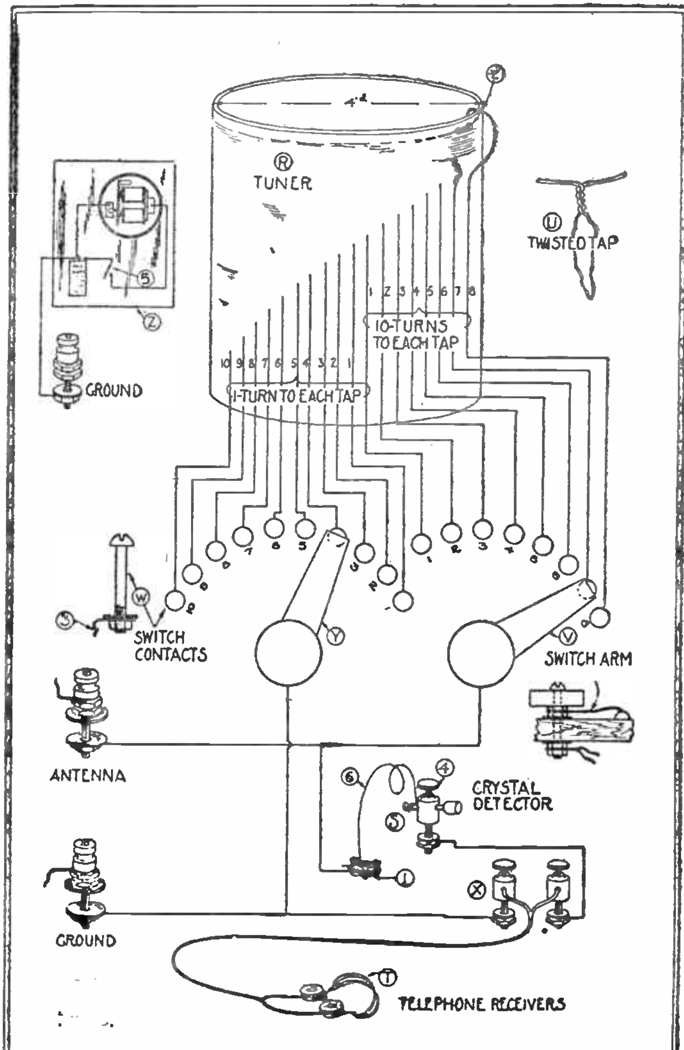

Fig. 9

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The crystal detector may be made up of a tested crystal, three wood screws, short piece of copper wire, a nail, set-screw type of binding post, and a wood knob or cork. The tested crystal is held in position on the wood base by three brass wood-screws as shown at 1, Fig. 9. A bare copper wire may be wrapped tightly around the three brass screws for contact. The assembling of the rest of the crystal detector is quite clearly shown in Fig. 10.

Phone (T, Fig. 9)—It is desirable to use a pair of telephone receivers connected by a head band, usually called a double telephone headset. The telephone receivers may be any of the standard commercial makes having a resistance of between 2000 and 3000 ohms. The double telephone receivers will cost more than all the other parts of the station combined, but it is desirable to get them, especially if one plans to improve his receiving set later. If one does not care to invest in a set of double telephone receivers, a single telephone receiver with a head band may be used; it gives results somewhat less satisfactory.

Accessories—Under the heading of accessory equipment may be listed binding posts, switch arms, switch contacts, test-buzzer, dry

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battery, and boards on which to mount the complete apparatus. The binding posts, switch arms and switch contacts may all be purchased from dealers who handle such goods or they may be quite readily improvised at home. There is nothing peculiar about the pieces of wood on which the equipment is mounted. They may be obtained from a dry packing-box and covered with paraffin to keep out moisture.

The following is a detailed description of the method of winding the coil, construction of the wood panels, and mounting and wiring the apparatus:

Tuner—See R, Fig 9. Having supplied oneself with a piece of cardboard tubing 4 inches in diameter and about ½ pound of No. 24 (or No. 26) double cotton covered copper wire, one is ready to start the winding of the tuner. Punch two holes in the tube about ½ inch from one end as shown at 2 on Fig. 9. Weave the wire through these holes in such a way that the end of the wire will be quite firmly anchored, leaving about 12 inches of the wire free for connections. Start with the remainder of the wire to wrap the several turns in a single layer about the tube, tightly and closely together. After 10 com-

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plete turns have been wound on the tube hold those turns snugly while a tap is being taken off. This tap is made by making a 6 inch loop of the wire and twisting it together at such a place that it will be slightly staggered from the first tap. This method of taking off taps is shown quite clearly at U, Fig. 9. Proceed in this manner until 7 twisted taps have been taken off at every 10 turns. After these first 70 turns have been wound on the tube then take off a 6 inch twisted tap for every succeeding single turn until 10 additional turns have been wound on the tube. After winding the last turn of wire anchor the end by weaving it through two holes punched in the tube much as was done at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 18 taps is slightly staggered from the one just above, so that the several taps will not be bunched along one line on the cardboard tube. See Fig. 9. It would be advisable, after winding the tuner as just described, to dip the tuner in hot paraffin. This will help to exclude moisture.

Upright Panel and Base—Having completed the tuner to this point, set it aside and construct the upright panel shown in Fig. 10.

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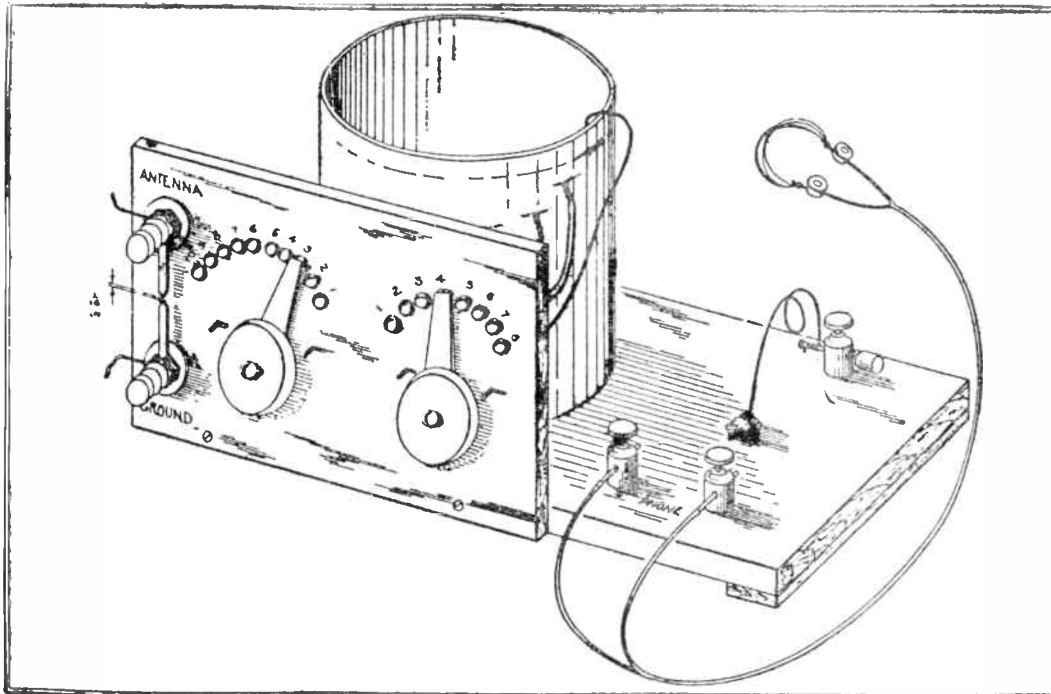

Fig. 10

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This panel may be a piece of wood approximately ½ inch thick. The position of the several holes for the binding posts, switch arms and switch contacts may first be laid out and drilled.

The "antenna" and "ground" binding posts may be ordinary ⅛ inch brass bolts of sufficient length and supplied with three nuts and two washers. The first nut binds the bolt to the panel, the second nut holds one of the short pieces of stiff wire, while the third nut holds the antenna or ground wire as the case may be. The switch arm with knob shown at V, Fig. 9, may be purchased in the assembled form or it may be constructed from a thin slice cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers together with a narrow strip of thin brass somewhat as shown.

The switch contacts (W, Fig. 9) may be of the regular type furnished for this purpose or they may be brass bolts equipped with one nut and one washer each or they may even be nails driven through the panel with an individual tap fastened under the head or soldered to the projection of the nail through the panel. The switch contacts should be just close enough that the switch arm will not drop

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between the contacts, but also far enough apart that the switch arm can be set so as to touch only one contact at a time.

The telephone binding post should preferably be of the set screw type as shown at X, Fig. 9.

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CHAPTER VII

THE WIRING OF A CRYSTAL SET

Directions for Operating—Uses of Test Buzzer—Approximate Cost of Parts of Home-made Crystal Set

HAVING constructed the several parts mentioned in previous chapter and mounted them on the wood base, one is ready to connect the several taps to the switch contacts and attach the other necessary wires. Scrape the cotton insulation from the loop ends of the sixteen twisted taps as well as from the ends of the two single taps coming from the first and last turns. Fasten the bare ends of these wires to the proper switch contacts as shown by the corresponding numbers in Fig. 9.

One should be careful not to cut or break any of the looped taps. It would be preferable to fasten the connecting wires to the switch contacts by binding them between the washer and the nut as shown at 3, Fig. 9. A wire is run from the back of the binding post marked "ground" (Fig. 9) to the back of the left-hand switch-arm bolt (Y), thence

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to underneath the left-hand binding post marked "phones."

A wire is then run from underneath the right-hand binding post marked "phones" to underneath the binding post (4, Fig. 9), which forms a part of the crystal detector. A piece of No. 24 bare copper wire about 2½ inches long, one end of which is twisted tightly around the nail (the nail passing through binding post 4), the other end of which rests gently by its own weight on the crystal (1).

The bare copper wire which was wrapped tightly around the three brass wood-screws holding the crystal in place is lead to and fastened at the rear of the right-hand switch arm bolt (v), thence to the upper left-hand binding post marked "antenna." As much as possible of this wiring is shown in Fig. 9.

After all the parts of this crystal-detector radio receiving set have been constructed and assembled the first essential operation is to adjust the little piece of wire, which rests lightly on the crystal, to a sensitive point. This may be accomplished in several different ways; the use of a miniature buzzer transmitter is very satisfactory. Assuming that the most sensitive point on the crystal has been found by

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method described in paragraph below, "The Test Buzzer," the rest of the operation is to get the radio receiving set in resonance or in tune with the station from which one wishes to hear messages.

The tuning of the receiving set is attained by adjusting the inductance of the tuner. That is, one or both of the switch arms are rotated until the proper number of turns of wire of the tuner are made a part of the metallic circuit between the antenna and ground, so that together with the capacity of the antenna the receiving circuit is in resonance with the particular transmitting station. It will be remembered that there are 10 turns of wire between each of the first 8 switch contacts and only one turn of wire between each 2 of the other contacts.

The tuning of the receiving set is best accomplished by setting the right-hand switch arm on contact (1) and rotating the left-hand switch arm over all its contacts. If the desired signals are not heard, move the right-hand switch arm to contact (2) and again rotate the left-hand switch arm throughout its range. Proceed in this manner until the desired signals are heard.

It will be advantageous for the one using

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this radio receiving equipment to find out the wave frequencies (wave-length) used by the several radio transmitting stations in his immediate vicinity.

The Test Buzzer (Z, Fig. 9)—As mentioned previously, it is easy to find the more sensitive spots on the crystal by using a test buzzer. The test buzzer is used as a miniature local transmitting set. When connected to the receiving set as shown at Z, Fig. 9, the current produced by the buzzer will be converted into sound by the telephone receivers and the crystal, the loudness of the sound depending on what part of the crystal is in contact with the fine wire.

To find the most sensitive spot connect the test buzzer to the receiving set as directed, close the switch (5, Fig. 9) (and if necessary adjust the buzzer armature so that a clear note is emitted by the buzzer), set the right-hand switch arm on contact point No. 8, fasten the telephone receivers to the binding posts marked "phones," loosen the set screw of the binding post slightly and change the position of the fine wire (6, Fig. 9) to several positions of contact with the crystal unit until the loudest sound is heard in the phones, then tighten the binding post set screw (4) slightly.

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Approximate Cost of Parts

The following list shows the approximate cost of the parts used in the construction of this radio receiving station. The total cost will depend largely on the kind of apparatus purchased and on the number of parts constructed at home.

Antenna—	
Wire—Copper, bare or insulated, No. 14, 100 to 150 ft., about	$ .75
Rope—3/8 or 1/2 inch. 2c per foot.	
2 insulators, porcelain	.20
1 pulley	.15
Lightning switch—30 ampere battery switch	.30
1 porcelain tube	.10
Ground connections—	
Wire (same kind as antenna wire.)	
1 clamp	.15
1 iron pipe or rod	.25
Receiving set—	
1/2 pound No. 24 copper wire double cotton covered	.75
1 cardboard box.	
2 switch knobs and blades complete	1.00
18 switch contacts and nuts	.75
3 binding posts—set screw type	.45
2 binding posts—any type	.30
1 crystal—tested	.25
3 wood screws, brass, 3/4 in. long	.03

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Wood for panels (from packing box.)		
2 pounds paraffin	.30	
Lamp cord, 2 to 3c per ft.		
Test buzzer	.50	
Dry battery	.30	
Telephone receivers	4.00 to	$8.00
Total	$11.00	$15.00

If nothing but the antenna wire, lightning switch, porcelain tube, crystal, telephone receiver, bolts and buzzer are purchased this total can be reduced to about $6.00.

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CHAPTER VIII

VACUUM TUBES

The V. T. the Keystone of Modern Radio—Invented by an Englishman, Perfected by an American—Difference Between Two and Three-Element Tubes

WHAT is the vacuum tube that has so revolutionized radio telephony? What is this thing that looks like an electric light bulb, yet makes audible the electro-magnetic waves that reach it from the air, via the aerial?

The vacuum tube made the radiophone famous. The V. T., as it is called for short, is the very keystone of the arch of modern wireless telegraphy. Without it this kind of telegraphy, or telephony, would have a very restricted use. With it we can telephone from Washington to Honolulu and from New York to Paris or London—and telegraph between these points at a rate of a hundred words or more a minute.

We can speak telephonically to flying airplanes or airships one hundred miles away, and miles high in the sky. We can talk from

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ship to ship across stormy seas many hundreds of miles as easily and often better than we can speak across the city by means of the ordinary land telephone.

In short the V. T. is an invention worthy to stand in the same category of merit as the steam engine, the power loom, the sewing machine or the gasoline engine. Moreover, unlike these inventions, it is extremely simple in construction.

Invented by Professor Fleming, an Englishman in 1904, an addition was made to it in 1907 by an American, Lee DeForest. This addition consists in the interposition of a zigzag of wire between the filament and the metal plate of the Fleming oscillation valve.

This addition formed the starting point for new developments by numerous inventors in America, England and France, which have finally given us the remarkable appliance called the three electrode vacuum tube. The modern V. T. can not only detect but can also magnify feeble electric oscillations, and, more important still, can generate very powerful vibratory electric currents if the circuit connecting the outer cylinder to the filament contains a battery or dynamo creating a steady electric voltage, and if this circuit is properly

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connected to another circuit joining the perforated plate or grid with the filament.

In this form it is called a *transmitting valve,* and we can by it generate the very powerful high frequency, or alternating electric, currents in an aerial wire which are necessary in wireless telegraphy or telephony.

These electric vibrations generate the electric waves which travel away through space from the aerial.

The aerial wire, therefore, resembles a sort of lighthouse which is radiating invisible light.

Transmitting valves are now made with silica or glass bulbs about the size and shape of a football. A large number can be harnessed together so as to generate enormous oscillatory currents.

At their great Carnarvon wireless station on the side of Mount Snowdon, Wales, Marconi's Wireless Telegraph Company have built a valve panel containing about sixty large valves, which can put into the great aerial wires currents of three or four hundred amperes. The electric waves so generated can be detected by suitable receiving apparatus, using audions as detectors and amplifiers, at all parts of the habitable earth.

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There are two other methods of creating the continuous electric waves now used in wireless telegraphy. One of these is by means of a high-frequency alternator, which is a complicated kind of dynamo not very different in principle from the alternators used for producing the low-frequency electric currents employed in electric lighting.

Machines of this kind are installed in the great wireless stations at Long Island and at St. Assise, near Paris. Again, there is another method which makes use of an electric arc. The audion tube has, however, great advantages in point of first class cost as against the high-frequency alternator, and it is superior to the arc generator because it gives a purer form of electric wave, less contaminated by a mixture of waves of various wave-lengths, called harmonics, and has other advantages in economy of power in signalling.

The growth and development of the three methods of electric wave generation—namely, by high-frequency alternators, arc, and transmitting tubes—will be watched by experts with great interest.

The Fleming valve was a small incandescent lamp highly exhausted of air and containing a filament of either tungsten or platinum

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wire which could be rendered intensely hot by passing an electric current through it. Fleming discovered that if a cold plate were also inserted in the tube it had a rectifying effect when used in wireless telegraphy. It was an improvement on the crystal.

Then DeForest as already stated developed the tube by putting another element in it which he called the "grid." The outer cylinder of this is formed of a solid plate of nickel; the inner one is either a spiral of nickel wire or else a cylinder of nickel gauze or network. These two cylinders do not touch each other or the filament, and they are attached to wires which are sealed through the wall of the bulb. (See Fig. 11.)

To explain the operation of this device I must remind the reader that modern research has shown that the atoms of which material substance are composed are themselves formed of still smaller atoms of electricity called electrons.

An atom of matter is a very small thing. If 250,000,000 atoms of copper or gold were put in a row, like marbles, touching each other the row would only be an inch long. But an electron is still smaller. Its diameter is probably only one hundred-thousandth of

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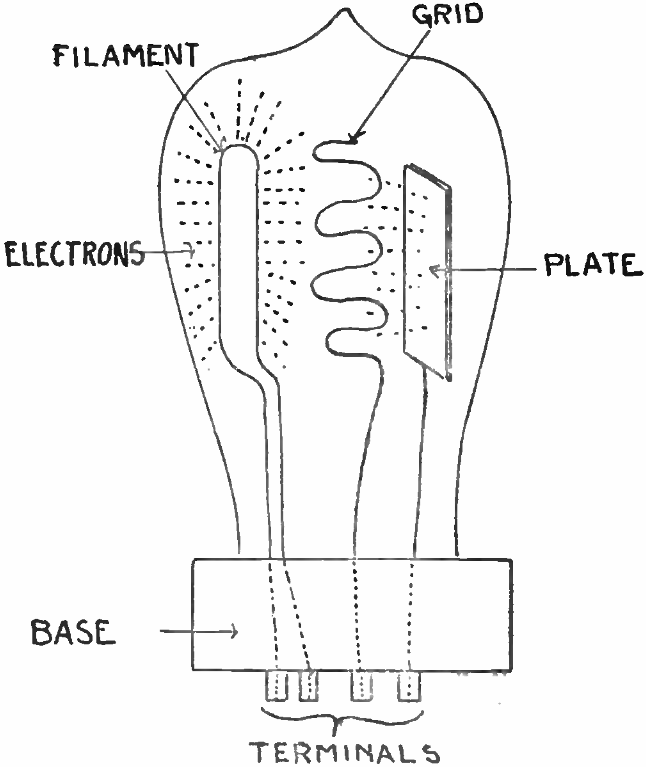

Diagram of Audion Tube, Showing
Relative Positions of Elements

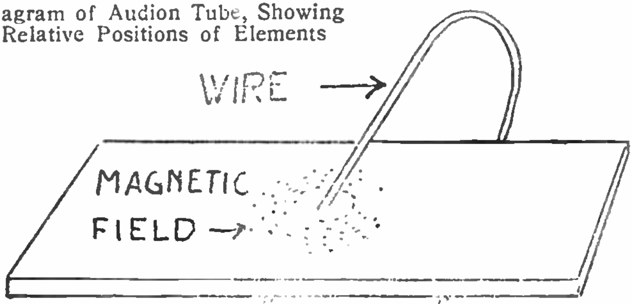

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Fig. 11 To Battery To Battery

that of an atom. Electrons are of two kinds, positive and negative, and an atom is a sort of solar system in which a number of negative electrons revolve round a nucleus composed chiefly of positive electrons. In the case of metals some of these negative electrons escape easily from the atoms and probably jump about from atom to atom like bees in a garden flitting from flower to flower.

The state we call an *electric current* in a wire is merely these free electrons as a whole drifting in one direction, or surging to and fro without ceasing their irregular motion. When a wire, say, of tungsten, is made very hot some of these free electrons escape from its surface, and this is called *thermionic emission*. If, then, we surround the hot wire by a cylinder of cold metal which is electrified positively, the escaping electrons are attracted to it, and the movement of negative electrons from the hot wire to the cold plate creates a thermionic current.

Since, then, negative electricity can pass from the hot wire to the cold metal cylinder, but cannot pass in the opposite direction, such a lamp, with cylinder enclosing the filaments, acts toward electricity as a valve in a pump

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acts toward water. It allows a flow to take place in one direction only. Prof. Fleming who was the first to use, in 1904, such an appliance in wireless telegraph, called it, as I have already said, an oscillation valve, a name subsequently changed to thermionic valve, and finally to *vacuum tube*.

The more anxious one becomes to obtain the best possible results from a receiving set the more necessary it is to pay proper attention to the plate voltage applied to the tubes. In detector tubes the most desirable voltage as shown by the characteristic curves is approximately 21-volts, and any large variation from the value will affect the quality and loudness of the reception.

In amplifying tubes the loudness of reception is materially increased by increasing the plate voltage which, with the ordinary tube, should be between 40 and 100-volts. Unless a voltmeter is used there is no quick way of knowing whether the B-battery is in good order. Should there be any failure of the battery or the circuit, the voltmeter indicates the trouble immediately.

It is sufficient to use one voltmeter and provide a selector switch or jack for connecting

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the voltmeter either to the detector or amplifier plate circuits, and, for this reason, it is desirable to select either a 50-volt or a 100-volt range instrument, depending upon the highest voltage used on the amplifier tubes.

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CHAPTER IX

PRINCIPLES OF V.T. TRANSMISSION

How Music and the Human Voice are Sent Through the Ether by the "Little Bottles"—Different Methods of V. T. Transmission

NOW let me briefly discuss the general principles of the vacuum tube as used in wireless telephony transmission. It is usual in wireless telephony to send out a steady stream of waves and to vary this stream by means of the sound vibrations of the voice.

This steady stream of waves can be obtained by means of various kinds of CW generators. The continuous stream, if received by an ordinary non-oscillating detector, will produce no sound whatever. If, however, the steady stream be modulated or varied by means of a microphone so connected in the transmitter circuit as to vary the amplitude of the continuous waves when the microphone is spoken into, the rectified signals at the receiving station will consist of a varying direct current.

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These variations will actuate a telephone receiver and produce sound waves of exactly the same nature as those produced by the speaker at the transmitting station.

The action is somewhat analogous to that of a simple telephone circuit consisting of a microphone, a battery, and a telephone receiver in series. A steady current flows from the battery through the microphone and through the telephone receiver.

This steady current produces normally no effect on the telephone receiver. If, however, the microphone be spoken into, its resistance will be varied and the steady current in the circuit will vary in strength, producing a sound in the receiver corresponding to the original speech.

In radio telephony a steady stream of waves is usually modulated by means of a microphone, the audio-frequency variations generally occurring at rates from 100 to 2,000 per second, the average frequency (sometimes termed the "mean speech frequency") being about 800 to 1,000 per second.

Two general methods of modulation are used at present; either the amplitude of the continuous waves is varied by the microphone, or the wave length is altered.

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If the receiving station is tuned to the carrier wave any variations of the wave-length of the latter will produce mistuning, and consequently a decrease of response in the receiver, depending on the degree of the variation. Sometimes both wave-length and amplitude modulation occur at the same time.

Some of the methods of modulating the continuous stream waves are:

(1) Connecting a microphone directly in the earth lead of a CW transmitter.

(2) Coupling a microphone circuit to one of the oscillatory circuits of a CW transmitter.

(3) Varying the output of a CW transmitting vacuum tube by using a microphone to vary the grid potential.

(4) The use of an additional grid, whose potential is varied by means of a microphone.

(5) Variation of the anode voltage or anode current of an oscillating transmitting tube by means of a microphone.

(6) Varying the output of an amplifying valve coupled to the aerial. The grid circuit is separately excited by a source of high frequency current and a micro-

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phone arrangement affects the output of the amplifier valve in one way or another.

(7) Causing a microphone to vary the resistance of an energy absorbing conductor connected across the aerial circuit coupled to the aerial circuit.

(8) The microphone is made to limit the oscillations in the grid circuit of an oscillator.

(9) The microphone varies the retroaction of an oscillating valve.

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CHAPTER X

OPERATION OF TUBES

Dangers to be Avoided—Why Filaments of Transmitting Tubes Should Be Energized by Alternating Current—How to Test Tube Circuits—Buzzer Modulation

ALTHOUGH the principles of construction and operation in the larger power tubes are no different from those applying in the case of the smaller ones, many effects that are negligible in the latter are somewhat magnified in the case of the larger tubes, and certain precautions are therefore necessary. The majority of accidents to power tubes and to their auxiliary apparatus occur during the period of development of circuits and testing and adjustment, rather than during operation, and a little care in making these adjustments will prove of advantage.

The following points, briefly enumerated, are all of importance and should be studied before the set is put into operation. Limited space prevents going into detail as to the reasons for some of the instructions herein laid

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down, but the amateur may be assured that they are the results of practical observation and experiment, and that he cannot well afford to ignore them.

The life of power tubes may be prolonged by mounting them in the proper position. Some should be operated in a vertical position, whereas others may be operated in either a vertical or a horizontal position. Instructions are given with the different makes of tubes. If mounted horizontally the plate should lie in a vertical plane with the seal-off tipped down. In powerful C.W. transmitting sets the circuit should be so arranged that the center tap on the filament coil, and also the negative lead of the direct current high voltage source, are both at ground potential relative to high frequency potentials in order to insure safety.

Great care should be taken to thoroughly insulate the grid and plate leads to the tubes, and the coil sections connected to these leads or any apparatus in them.

In order to guard against excessive transient voltages in connection with V.T. tubes a protective gap should be provided at, or near, the socket terminals between the grid and terminal and one of the filament terminals. One-

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sixteenth of an inch is correct for a 50-Watt tube, and one-eighth of an inch for a 250-Watt tube.

Occasionally, in the parallel operation of power tubes, ultra high frequency oscillations develop in the plate and grid circuits, which prevent the realization of full output and cause excessive plate and grid currents. This effect may be avoided by inserting an inductance of a few micro-henries (ten turns in one layer on a tube one inch in diameter is suggested) in one or more of the individual grid leads of each tube as close to the grid terminal of a socket as possible. The protective gap should be placed between this coil and the grid terminal of the socket. The best arrangement is to mount a gap directly on the socket terminals and one terminal of the coil directly to the grid terminals of the socket.

One method of modulation employed in a vacuum tube radio transmitting equipment utilizes a tube as a modulator in addition to the oscillator tube. The plate current for these two tubes is fed through an audio frequency reactance. In a radio telephone transmitting equipment the degree of modulation is of equal importance to the amount of antenna current as far as the strength of the re-

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ceived speech is concerned. The antenna ammeter does not usually indicate whether the output is being modulated in a normal manner. One method of checking this is to insert a small lamp in the plate circuit of the amplifier. This flashes up when the microphone is spoken into and acts as an operating indicator of the microphone and modulation circuits. A type of lamp should be chosen that will show a low degree of brilliancy with the plate currents obtained on the tubes used. Even for the five-Watt size of tubes these lamps are easily obtainable. Try miniature lamps of the automobile type.

The filaments of transmitting power tubes are preferably energized by alternating current which gives an added factor of safety and prolongs the filament life.

In adjusting the temperature of a filament the amateur should always use a voltmeter rather than an ammeter, and the voltmeter should be connected directly to the socket connections in order that the voltage drop across the filament may be measured. If tungsten filaments are operated at constant voltage rather than constant current, it will increase their life in the ratio of three to one.

If alternating current is not available the

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filaments may, of course, be energized from a D.C. source of suitable E.M.F. It is emphasized, however, that the life of a vacuum tube is considerably prolonged by A.C. filament excitation, and particularly if the filament voltage is maintained at constant value.

A "blow-out" of the vacuum tube is the bogey that haunts many an amateur who has been out-of-luck with his V.T.'s.

It is unwise to overload a radiotron or any other power tube continuously, as its operating life will be seriously curtailed. It is a much better plan and more economical to operate two tubes in parallel than it is to force one tube to deliver a power output far in excess of what it is rated for; in fact great economy will result from burning tubes slightly below normal brightness.

For instance, it can be shown that to double the filament emission will reduce the operating life of the tube to one-fourth, whereas, by operating the filament at 95% of its rated voltage, the life will be doubled.

When first testing the circuit, or when the set has not been operated for some time, it is wise to cut down all voltages to one-third of the normal voltage. This will greatly reduce the possibility of burning out the tube through

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a wrong connection which has been overlooked, as a fault will then instantly be detected before the damage is done.

In a radio telephone transmitting circuit of the usual type a modulator tube is employed and a buzzer is often substituted for the microphone when it is desired to send out interrupted continuous waves. This imposes voltage strains on the oscillator tube, and if an over-voltage is also applied to its plate the voltage between grid and filament may be excessive. The protective gaps described in a previous paragraph are a safeguard against breakdown due to this voltage.

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CHAPTER XI

AERIALS

The Functions of Antennae—Hints on Construction of Aerials—Different Types of Aerial—"Skin Effect" on Different Kinds of Wire

ALTHOUGH any alternating current will cause a disturbance in the ether regardless of the size or shape of the circuit, in order to create the maximum disturbances possible with the power available, it is necessary to erect an "aerial."

An aerial or antennae is a system of wires stretched above the surrounding objects and connected to the radio set. The aerial can be used for either transmitting or receiving, a switch or other transfer means being used to connect it to one or the other according as the station is sending or receiving messages.

The wire used in aerials is either bare copper, phosphor-bronze, or copper clad steel and sometimes galvanized iron. The ends of the wires are insulated with specal insulators and the wire lead into the house through an

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insulating tube known as a "bulkhead" insulator.

In the installation of a receiving set for the reception of wireless telegraph or telephony, the following hints with regard to the antenna may be of some value.

Care should be exercised in the selection of a site for the erection of the antenna. Avoid placing an antenna in such a position that its wires are parallel to lighting lines, high tension power lines or telephone lines. If there are any such wires near the contemplated site, be sure to erect your aerial so that its plane will be at right angles to and as far as possible away from such wires. It is very important to observe these precautions if the best results are to be obtained.

The antenna may be erected between two trees if available or from the corner of a house or building. The best method, however, is to erect two masts and support the antenna between these.

The antenna may be erected at any convenient height. The higher the antenna, however, the better will be the results. An antenna erected at a good height away from surrounding buildings is less liable to pick up static, which greatly interferes with the recep-

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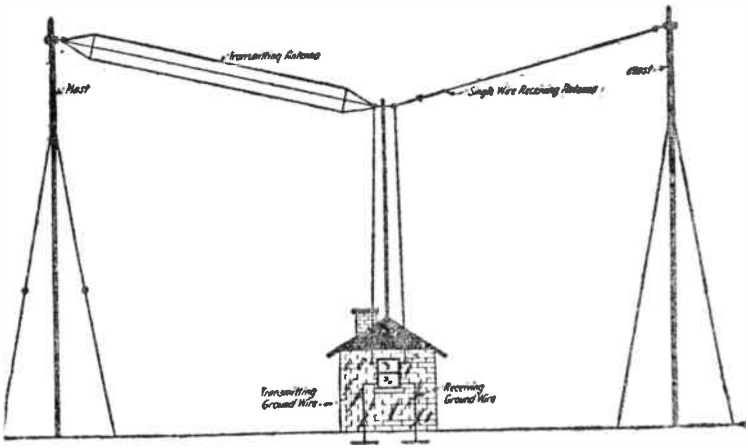
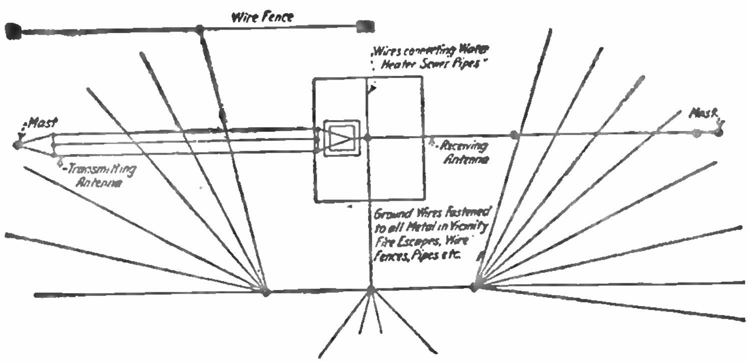


Modern Amateur Antenna Installation.



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Overhead View of Same.

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tion of radio signals, especially music or speech.

There are numerous types of aerials which may be used for receiving purposes. The best types for the amateur will be either the straight-away inverted "L" type or the straight-away "T" type. These aerials receive their name from the method of connection of the lead in wire. In the inverted "L" type the lead-in is connected from the end of the aerial while in the "T" type the lead-in wire is taken from the center of aerial. The inverted "L" type is generally employed and is the better for receiving.

The aerial may consist of any number of wires. While a one-wire aerial will give excellent results in receiving, an aerial consisting of two or four wires has greater capacity and is to be preferred. If it is desired to receive from short wave-length stations, we would suggest that aerial be not more than 100 feet in length.

Another important feature in connection with the antenna is the lightning ground connection. All antennae should be "grounded" when not in use. An antenna properly grounded acts as protection against lightning in the same manner as lightning rods neutra-

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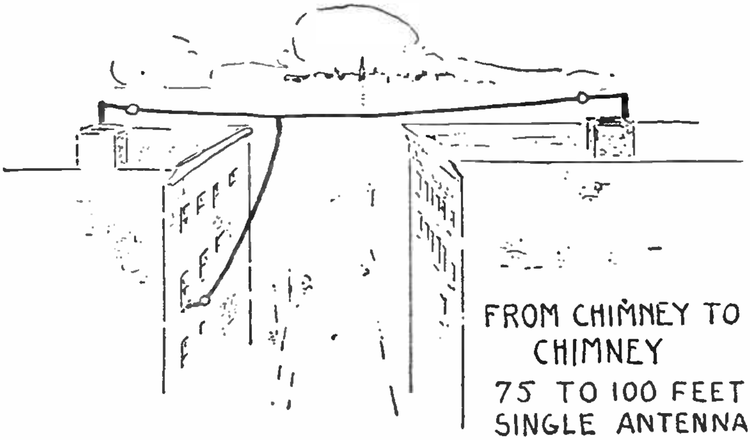

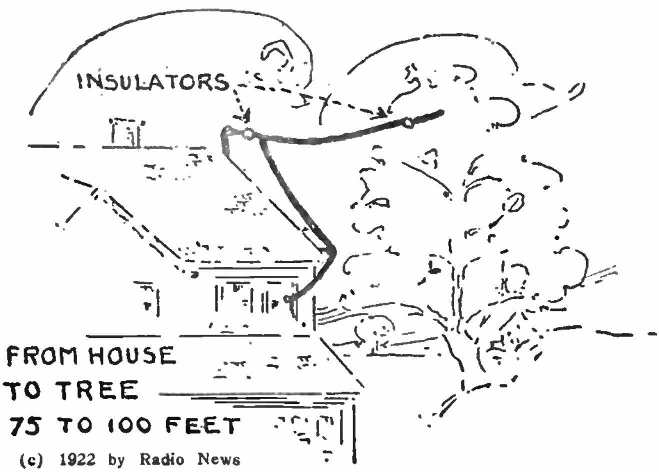

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lize static charges in its vicinity. A good ground connection may be made to a water pipe or if such is not available to a rod or pipe driven into the earth in a damp spot. A single pole, double throw-switch of large capacity should be placed in circuit between the aerial lead and the ground connection, No. 4 stranded rubber covered wire being used for connection from the ground switch to the ground connection.

A ground connection must also be provided for the instrument. This may be made on a water pipe, a radiator or any metal which is a good conductor of electricity and which is also connected to the earth. No. 12 or 14 wire may be used for connection from the ground to the instruments.

Radio frequency currents, conducted by wires at the sending and receiving stations, travel only along the surface exterior of the wires and do not penetrate to the core, because of the phenomenon known as "skin effect." The loss of radio energy in the wires depends on the electrical conducting properties of the surface metal.

In so far as electrical conducting properties are concerned, pure copper is the most efficient commercial metal, but it lacks suffi-

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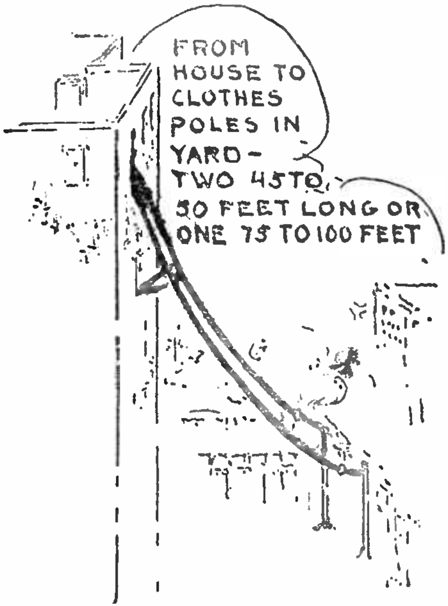

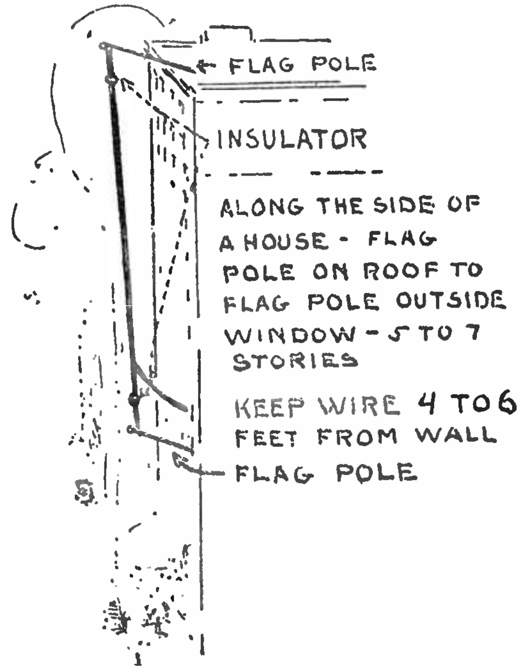

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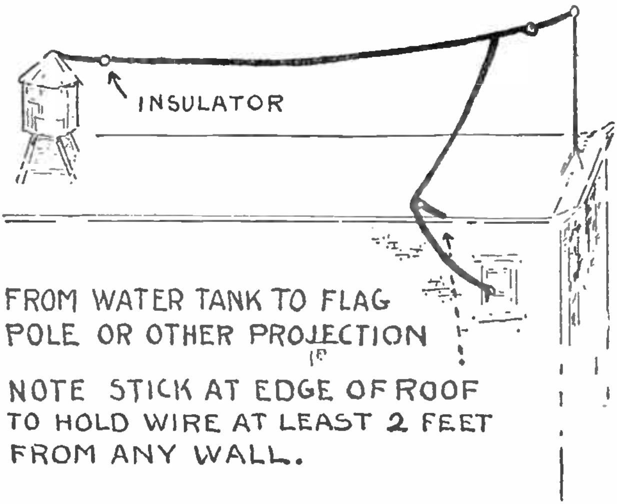

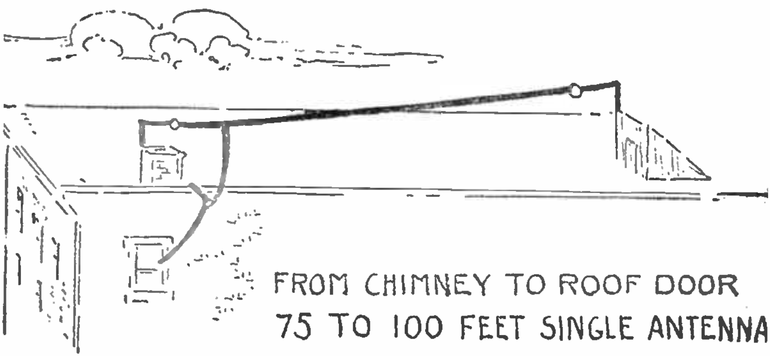

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cient strength for a great many purposes. Bronze is also objectionable because of its poor electrical conductivity—approximately two-fifths as much as copper of equal size. Much more radio energy is lost in bronze wire than in copper.

The core of a wire carries no radio frequency current and performs no electrical service, because of this radio frequency phenomena called "skin effect." The core may therefore be made to perform a greater mechanical duty. Hence the ideal wire for radio antenna should have a core of great strength (steel) and an outer covering of high conductivity (copper).

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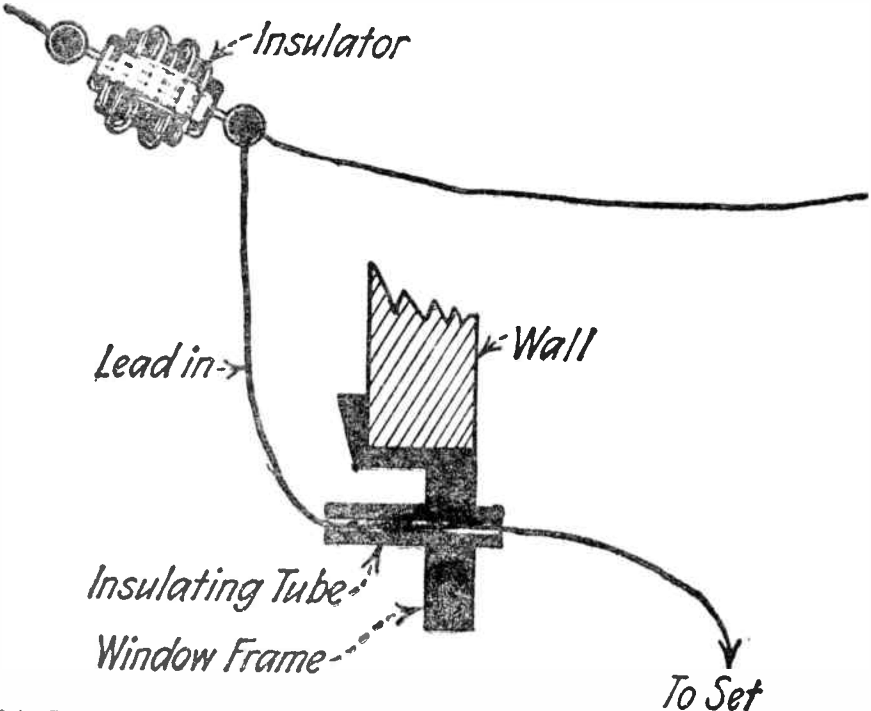

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Method of Bringing in Lead-In from Antenna.

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CHAPTER XII

GROUND CONNECTIONS

Common Faults of Aerials—How to Put a Metal Roof to Use—Proper Place for the Lead-in—Uses of the Counterpoise

IF you have not a good aerial and your ground connections are defective you cannot expect to be able to sit in on the radio broadcasting concerts.

The commonest faults with aerials are that they are too short and are not far enough from the ground. You cannot expect to be able to pick up much with ten or fifteen feet of wire strung near to the earth like a clothes-line.

The aerial should be at least fifty feet clear of all obstructions if you are using a crystal set. Of course, if you have an audion detector, then height is not so essential. However, even with a vacuum tube the aerial should not be less than twenty-five feet above the ground or roof.

For receiving sets it is not necessary to use costly copper or bronze wire for your aerial.

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Galvanized iron wire, which may be bought for about four feet for a cent, is good enough. A single wire aerial is just as good for receiving as a two or more wire antenna. The insulators may be simply porcelain cleats that may be purchased at any electrical store for two cents apiece. Be sure and have the lead-in clear of tin roofs and gutters.

By the way, if you have a metal roof on your house this need not be a hindrance to reception. If your aerial is over the tin roof solder a lead to the roof and connect it together with the usual ground wire to the post marked "ground" on the receiving set. This is especially helpful in receiving music.

When making the ground connection to the water pipe or radiator do not merely wrap the wire around. Solder it. The lead-in from the aerial should also be soldered where it makes the connection with the aerial.

For efficiency the lead-in should be connected to the aerial at the end nearest to the broadcasting station. That is, if the transmitting station is to the west of your receiving station, the aerial should be hung from east to west with the lead at the western end. If there is broadcasting both sides of you put the lead-in in the middle of your aerial.

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Because of their compactness, and because they do away with the necessity of crawling up on roofs to adjust antennae, loop aerials are becoming increasingly popular with owners of radiophone receivers.

It is the loop aerial that is used in direction finding work. Radio compass stations are erected all along the coast of the United States and other countries, enabling ships to determine their exact position at any time in a fog or heavy storm in which they might be carried out of their courses.

The same system is used on airplanes to enable the pilots to know their direction when flying in the clouds, or at night, and at the present time this device is being used with success on a number of our Army and Navy machines.

Undoubtedly owing to its many advantages over the ordinary type of antenna the loop aerial is the aerial of the future, but further improvements must be made in order to perfect this wave collector.

A loop aerial suitable for receiving the broadcasted music should be about four feet square, wound with thirty-five turns of No. 8 D.C.C. wire mounted so that it can be ro-

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tated. Remember that a loop aerial cannot be used with a crystal receiving set unless you are within two or three miles of the transmitting station, and even then you would get very poor results with it.

With an audion receiver a loop is effective anywhere within thirty miles of the transmitter, and with an audion detector and 2-step amplifier the loop will be effective up to 500 or 800 miles for telegraph signals, but for telephone work for not more than 200 miles.

Some loop enthusiasts use a ground connection also with a loop connected to the usual ground post on the receiver. This brings in the signals much clearer, although if the loop is used for direction-finding work, a ground connection cannot be used.

A loop aerial helps greatly to eliminate static, and during the summer months when the static is usually troublesome, the radiophone fan should experiment with different sizes of loops and different hook-ups.

A good idea when attempting to receive long distance signals, or "DX work," is to construct a counterpoise.

A counterpoise is an antenna constructed near the ground. It is the same as the more

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familiar antenna except that it is used in place of a ground connection. It must be at least one foot above the ground.

In localities that have sandy or very rocky soil this will help materially in bringing in distant stations. You may not notice any great difference at first, but on the first clear cold night the distant stations will roll in. Try it with the ground lead and then without it.

With a C.W. (continuous wave) transmitting set I have, when using a regular water-pipe system, radiated only two-tenths of an ampere. After building a counterpoise the radiation jumped to eight-tenths of an ampere. Don't miss any chance you may get to add another ground connection.

Before the war I had a crystal receiving set which consisted of a double slide tuning coil, a fixed condenser and a pair of phones along with a galena detector. There was no music to listen to in those days, and one had to learn the code before he could get any "dope" out of the air.

I had a ground connection to a well about 100 feet deep, and at first this seemed to serve very well. One day I constructed an aerial for receiving Arlington as the tuning coil

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would not go above 1800 meters. It snowed the first night, and the storm carried away the makeshift antenna. Of course this grounded my regular antenna, and I had to disconnect the new antenna from the set.

Noticing that the far end of it was lying in the snow I connected it to the ground wire on the antenna switch. A great difference in signal strength was at once noticed. WSE and NAH came in clearly and loudly. My station was about forty miles from New York. The first night I heard WBF, NAM and NGE, and a few others which I had never picked up before.

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CHAPTER XIII

STATIC

Nature's Own Transmitter—The Action of Lightning on Receiving Sets

LIGHTNING, "summer static," nature's own wireless transmitter, is the bugbear of amateur radio.

Static is more troublesome to the more sensitive receiving sets where several steps of amplification are in use. Static is more prevalent in summer, due to the higher temperature of the air. Heat electricity is formed in the air and gradually collects upon the antenna until a sufficient charge has been built up to break down the natural resistance of the receiving set.

It then discharges through the primary of the receiving transformer to the ground. Due to the highly dampened quality of this discharge it permeates the whole receiving set and can not be tuned out.

Another cause of static is the close prox-

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imity of two clouds, one of which is charged with negative electricity, the other with positive. The resulting spark discharge sets up a chain of highly dampened oscillations which are impossible to tune out.

These "strays" as they are called, are much more prevalent on long waves than on the shorter ones used by the broadcasting stations. In summer, when static is so strong on, say, 10,000 meters that nothing but a continuous roar can be heard, only occasional static scratches will be heard on 200 meters.

No practical method has yet been discovered that will eliminate static, although there are ways by which it may be reduced. The most common method is by the use of a very loose coupling between primary and secondary of the receiving transformer. By tuning the secondary into very close resonance with the primary at such frequency at which reception is desired, the signal will readily pass through—but moderate strength static of no definite wave length will pass through to ground without affecting the secondary circuits in respect to which it is out of resonance. The very strong static will, however, force itself into the secondary.

Another method for reducing static is by the

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use of an antenna of small capacity; that is, one that offers only a small surface for "strays" to collect on. An antenna having one wire will have this effect. A loop antenna, due to its high directional qualities, will almost entirely eliminate horizontal static (that which comes from a long distance, caused by a distant storm). This will not overcome local static, however.

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CHAPTER XIV

THE ARMSTRONG FEED-BACK CIRCUIT

Regenerative Circuit Most Revolutionary Contribution to Wireless Art—The Discovery One of the Romances of Radio—How it Made Modern Broadcasting Possible

THE most important contribution to radio art since the perfection of the vacuum tube is the much-discussed "Armstrong Feed-Back Circuit." But for Armstrong's circuit there would be no such thing as radiophone transmitting by means of vacuum tubes. In other words, but for Armstrong you could not get the wonderful musical programs and other forms of entertainment that are now daily broadcasted by hundreds of stations throughout the United States.

Certainly an arc transmitter could be used, but the sounds that would be projected through the air by this means would be so inextricably mixed up with "clicks, hisses, gurgles and howls" that nobody would have the patience to listen to it. No trans-Atlantic

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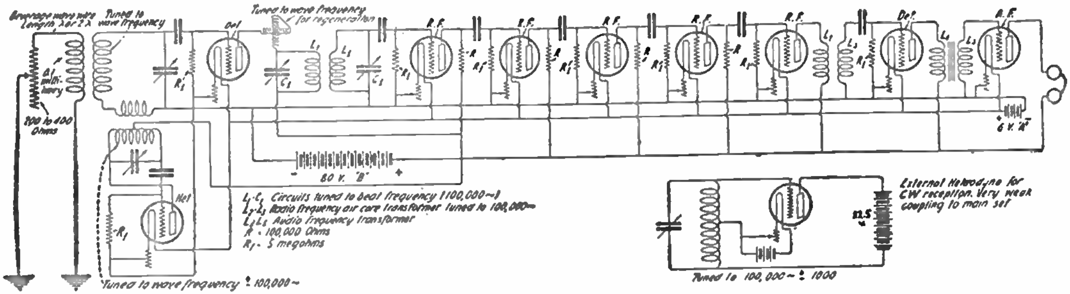

This is the Super-Heterodyne Circuit Used by Paul Godley, at Ardrossan, Scotland, During his Epoch-Making Trans-Atlantic Tests. With this Circuit Mr. Godley Received Signals from Many Amateurs in the United States.

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conversation can be carried on without the Armstrong principle being employed; even the modern multiplex form of wireless telegraphy and telephony must pay tribute to Armstrong.

Edwin H. Armstrong is a young American. The story of his discovery is one of the great stories of radio. He became interested in wireless when a boy in short pants. When he first hit upon his "idea" he could not for a long time get anybody interested in his work. How could he discover anything? He was too young! Finally Professor Michael I. Pupin, Director of the Marcellus Hartley Research Laboratory of Columbia University, with whom he was at the time studying, placed at his disposal the facilities of the Hartley laboratory in which to perfect his invention. This is Prof. Pupin's tribute to Armstrong:

"The Armstrong Feed-Back Circuit is one of the most important, if not the most important, invention in the wireless art. It is the invention of employing in connection with an audion a coupling which enables a local battery to contribute its energy to the amplification of a signal received in a wireless station. The contribution obtained in this manner

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from the local battery or the local source of energy may be made as large as we please within certain definite limits. Armstrong was the first to employ this coupling—or as it is called, the 'Armstrong Feed-Back Circuit,' and he did it while he was still an undergraduate at Columbia University.

"The invention enabled him to make another most important step in wireless telegraphy, and that is the construction of a vacuum-tube oscillator. When the feed-back circuit energized by the local source contributes more than a certain definite amount, then the system of circuits becomes an electrical oscillator, oscillating at the perfectly definite period which depends upon the inductance and the capacity of the controlling circuit. By varying either the inductance or the capacity or both, we can produce any period of oscillation between a few periods per second and many millions per second, and the oscillation, once established, maintains its pitch indefinitely.

"It is a generator of electrical oscillations, maintaining its pitch with a degree of accuracy never before obtained by any apparatus constructed by man.

"The importance of the feed-back circuit

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in the reception of wireless electrical oscillator, not only in wireless telegraphy but also in wire telegraphy and other departments of applied electricity, cannot be over estimated.

"It is admitted by those skilled in the wireless art that the ordinary electro-magnetic generator of high power will before long be superseded by the vacuum-tube oscillator, which also will bring about more or less reconstruction of wireless transmitting stations.

"It goes without saying that long distance radio communication and radio phone broadcasting would be impossible without this invention."

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CHAPTER XV

SOME HOOK-UPS

A Simple Long Wave Receiver—Self-Heterodyne Circuits —Short Wave Regenerative Receivers—A Hook-up Without an Aerial

THIS is, perhaps, the best type of simple long wave receiver. The use of the separate heterodyne permits the receiver to be tuned exactly to the wave. The beat note is obtained by throwing the heterodyne slightly above or below the signal it is desired to receive. Both circuits should be calibrated for easy manipulation. As this method of reception is designed for long waves, honeycomb coils or other good compact inductances are recommended.

LONG WAVE RECEIVER WITH SELF-HETERODYNE

A most popular type of long wave receiver is shown in Fig. 12. The detector tube is made to oscillate thus producing a beat note

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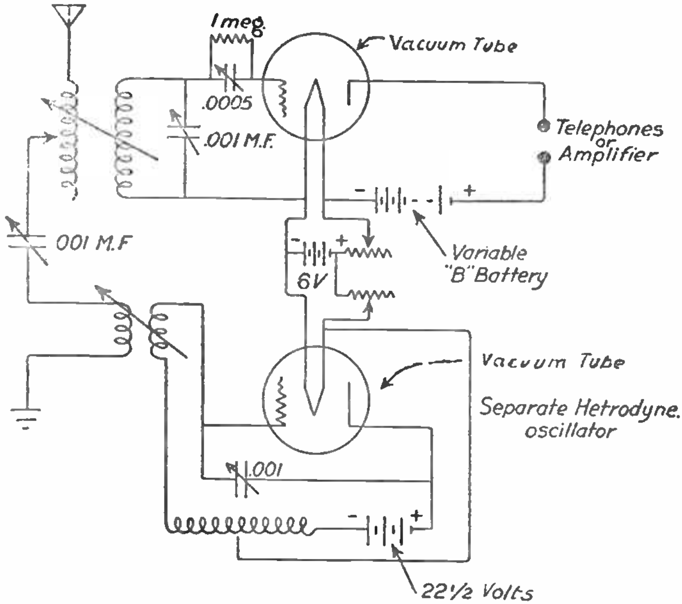

Fig. 12
Receiving Circuit Showing Separate Heterodyne.

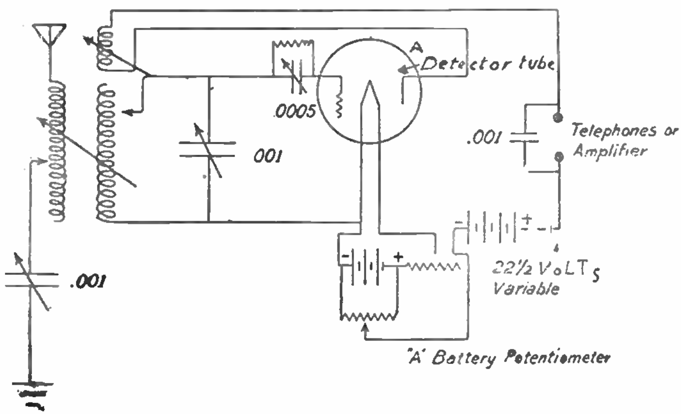

Fig. 13
Feed-Back Regenerative Circuit.

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when slightly off tune with the incoming signal. Honeycomb or other good compact coils are recommended.

Always vary the "B" battery when putting a new detector tube in the circuit as the sensitivity varies greatly with the value of the "B" battery. The potentiometer shown is of great value in obtaining the exact point.

With a circuit of this kind and with a two stage audio frequency amplifier it is possible to copy practically all the trans-oceanic radio stations operating on the long waves. For this type of work the aerial should be as long as possible and may consist of a single wire. Best results will be obtained when the wire is as high as possible and above surrounding objects, but even low wires will give remarkably good results.

In Fig. 13 is shown a simple circuit that will give excellent results in this type of apparatus. It will be noticed that the use of a variable grid condenser is shown. While not absolutely necessary at times this feature is of great value, especially when the unit is to be used for detection at different wave lengths.

An "A" battery potentiometer is shown on the grid circuits of the amplifier tubes. This feature is of very great value when clear tele-

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phone speech is desired as the value of negative current, "C," on the grids determines the operation of the tubes. The same "B" battery may be used for both detector and amplifier, the detector battery being tapped off at about 18 to 20 volts. Sixty volts is recommended for the amplifying tubes.

Any good type of audio frequency transformer may be used. As the amplification of this type of apparatus is quite great it is necessary to take precautions against internal oscillations, or "howling." This condition is brought about through a feed-back of energy from one tube to the other. In general, by placing the transformers as far apart as possible (about six inches), and placing the cores of the transformer at right angles, the trouble will be eliminated. (Fig. 14.)

The selectivity of this receiver is very great. It is suitable for continuous wave, or C.W., reception, with or without shields. The use of shields, however, is recommended.

Receivers of this type have been constructed using the same coil as grid coil and coupler coil. Where this type of construction is used it is necessary to loosen the coupling between the primary circuit and the grid and coupling coil. Wonderful results will be ob-

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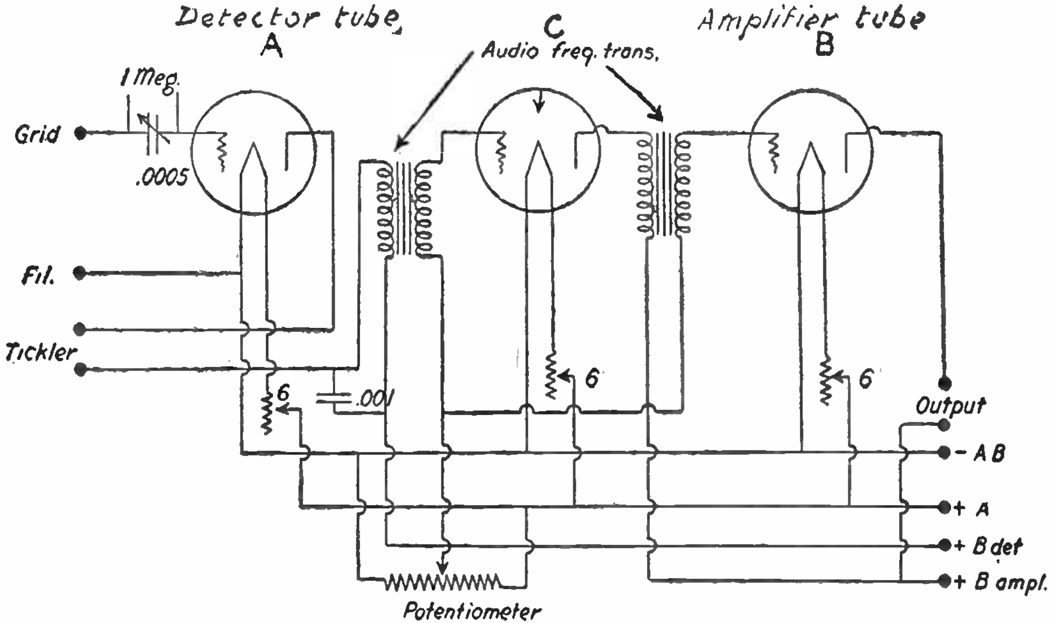

Fig. 14
Wiring Diagram of Audion Detector and Two Stages of Audio Frequency amplification.

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tained where "Litzen Draht" wire is on all the forms. Operation will be materially improved by keeping the leads to the vacuum tubes short as possible.

This is probably the best of the short wave regenerative receiver connections. The circuits must be properly designed, however, in order to obtain good results. The value of the grid circuit condenser (Condenser A) should not exceed .0007 mf., and best practice limits it to below .0005 mf. To cover an appreciable wave-length range, therefore, it is necessary to design the grid coil very carefully. This coil may be made variable but it is not recommended.

There are hook-ups and hook-ups. So rapid has been the development of the science of radio that they are almost as numerous as the sands of the seashore. When the time comes for you to decide upon the circuit you are going to use, it all depends upon the apparatus you have at your disposal.

Fig. 15 shows a circuit which can be made up by using a small amount of relatively simple apparatus, to be used without an aerial. The values of the constants of the circuits are the same as those used in any ordinary short-wave receiver with one stage of audio ampli-

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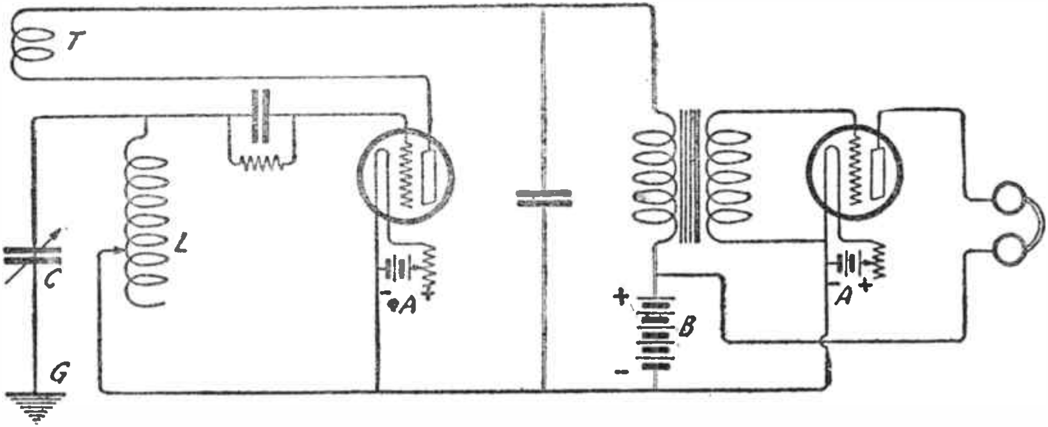

Fig. 15
Hook-Up for Receiver Without Aerial with One-Step of Audio Frequency Amplification.

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fication. It is not necessary to use separate "A" batteries as shown. The tuning is accomplished by varying L in steps and making fine adjustments with C. The ground employed was the water pipe of a local heating system.

Using the above circuit, the writer, located just outside of Asbury Park, N. J., was able to hear the concerts sent out by KDKA, the broadcasting station at East Pittsburgh, Pa. KDKA was using 650-watts in the antenna. I have also heard the high power stations of the East Coast and Canada with a single tube and without an aerial.

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CHAPTER XVI

THE NEWEST CIRCUITS

The Loose Coupler, the Variometer and the Vario-Coupler —Honeycomb Coils—The Shielding of Panels

A LOOSE coupler is another form of tuner used in place of a tuning coil. It provides much sharper tuning because of the fact that the antenna and ground are not connected directly to the rest of the receiving set. The outer winding on the loose coupler is called the *primary,* and the inner coil the *secondary*. The energy is transferred from the primary to the secondary. (See INDUCTION in Chapter 2.) The primary inductance is usually made variable by means of a sliding contact, and the secondary made variable by means of a rotary switch. In short, and in non-technical language, it is with a loose coupler that you *tune out* the stations or music that you do not want, and *tune-in* the ones you desire.

A vario-coupler is the same as a loose coupler except that the secondary rotates

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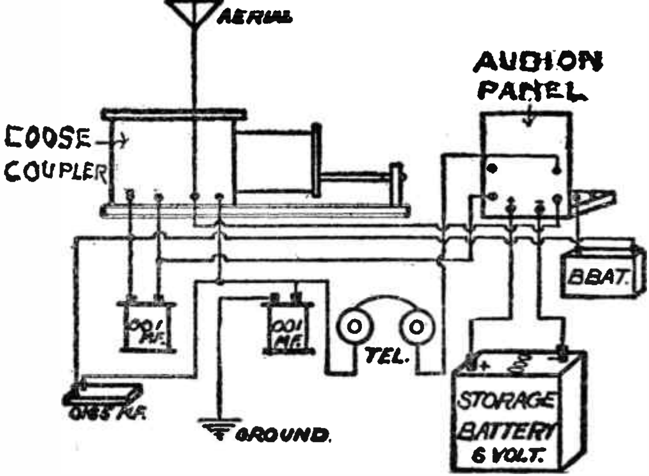
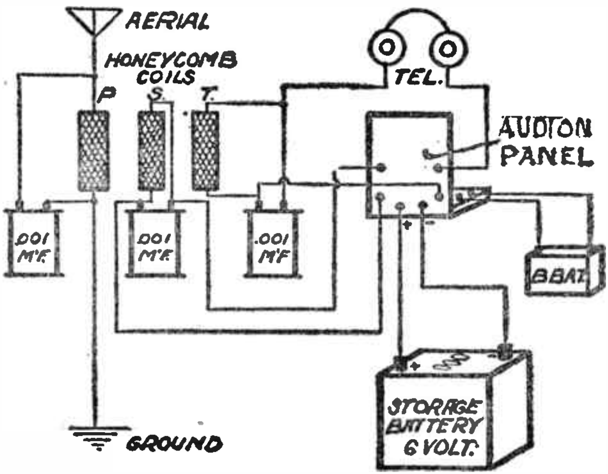


Plain Audion Hook-Up Using Loose Coupler and Two Variable Condenser as Tuner.



Feed-Back, or Regenerative, Hook-Up Using Three Honeycomb Coils.

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within the primary instead of sliding in and out of it. The secondary has no taps on it.

A variometer is two inductances, one rotating within the other, and both of them connected in series, or with one terminal of the inner one connected to one terminal of the outer one. The two leads left are the terminals of the variometer. This provides a continuously variable inductance. Tuning is done in the same manner as with a variable condenser, except that you vary *inductance* rather than *capacity*. When we say "varying the inductance" we mean that we change the electrical *length* of the instrument. When the wire on the rotating part of the variometer is as close as possible to the stationary part, the *inductance* is lessened; when the rotating part is at right angles to the stationary part, then the inductance is lengthened, making it possible to receive shorter or longer waves at will.

There is, I have found, a decided lack of information on short wave reception with honeycomb coils. Much "high volt" and bitter language has been expended on the coil with a sweet name. Inexperienced radio fans after buying a complete set of them have cast them into the discard in disgust.

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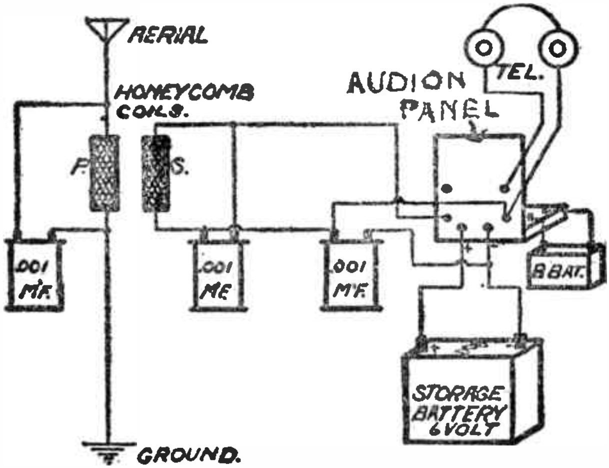
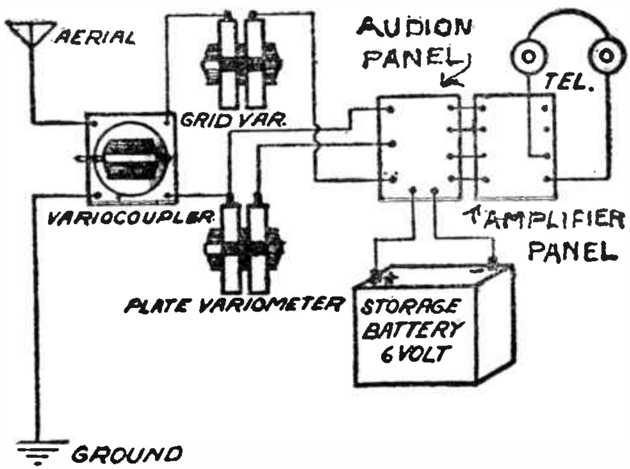


Plain Audion Hook-Up Using Honeycomb Coils



Hook-Up of Regenerative Receiver Using Variometers as Tuners and One-Step of Audio Frequency Amplification.

"Capacity" between the secondary coil leads, more than anything else, causes dissatisfaction when copying amateur stations and other short wave signals, such as music.

Capacity may be practically ignored when receiving longer wave lengths, but for short wave reception capacity between the secondary leads should be eliminated if you are keen about getting the very most out of your receiver.

Keep the secondary leads as far away from each other as practicable, and, if possible, at right angles to each other. By secondary leads I mean those that run from your honeycomb coil mounting to the grid condenser and B battery.

Other points of great importance are the length of the leads between the grid condenser and the detector tube, and those between the secondary and the B battery. These must both be as short as possible.

In tuning for long distance signals loose coupling is absolutely essential. If the tickler is set so that the bulb does not oscillate, but is near the oscillating point, and the primary coil is moved away from the secondary, the

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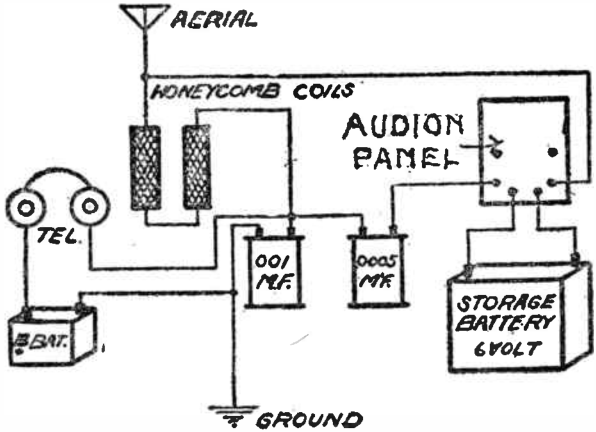
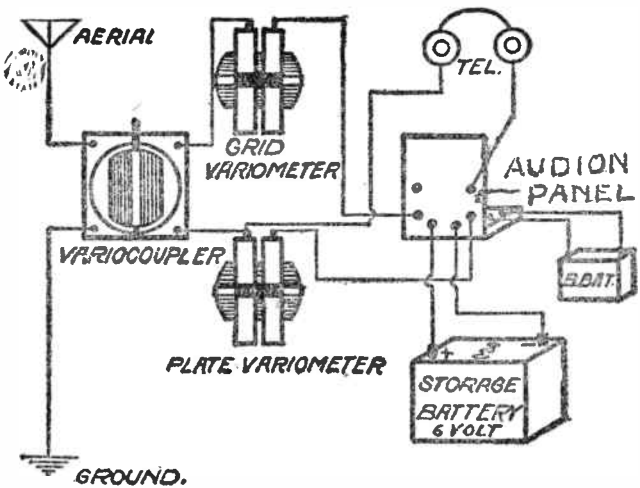


Simple Hook-Up Using Two Honeycomb Coils as a Variometer



Hook-Up of Regenerative Receiver Using Audion Detector.

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further you move the primary the more sensitive the set becomes.

Moving the primary away from the secondary brings the set slowly to the oscillating point and makes it very sensitive. It also cuts out to a considerable degree interference from nearby stations. It decreases the strength of signals from stations within a hundred miles, but increases the strength of signals from stations of from 400 to 600 miles away. Of course, this is assuming that you have a two-step amplifier and an audion detector.

If you have only a few sets of coils there is no need for you to throw away more money on other sizes in order to enlarge your wave-length capacity.

Connect a 23-plate variable condenser in series with your aerial, and then you can go below the wave lengths the particular coil is supposed to handle. Of course, in the secondary circuit a coil that is smaller than the one used in the primary must be used if the coils are to be utilized in this manner.

It is generally conceded by all modern radio experts, that a shielded panel is desirable in a number of respects, chief among which is the elimination of capacity effects from the

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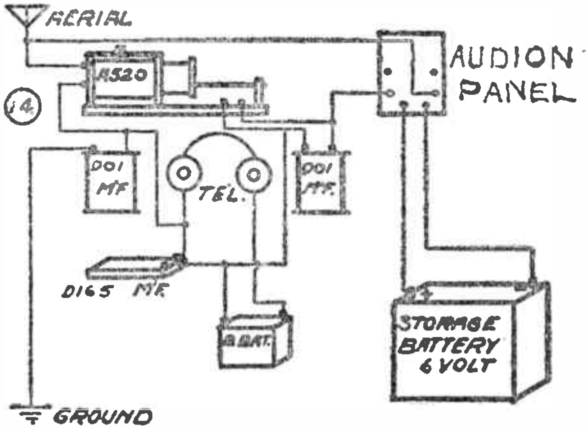
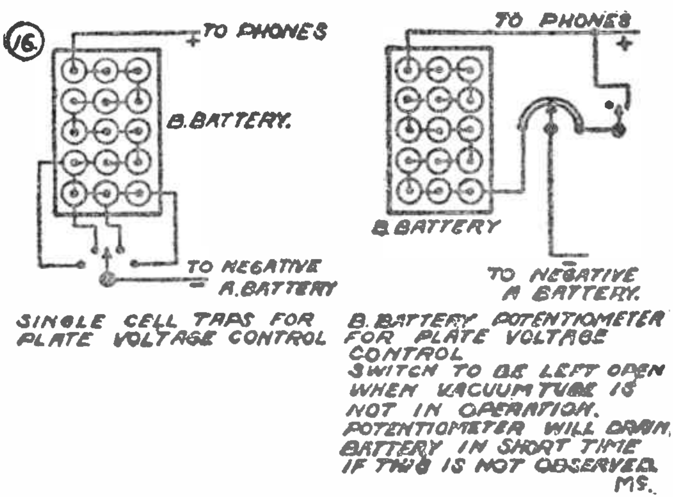


Hook-Up Using Loose-Coupler as Tuner With Audion Detector.



Method of Connecting "B," or Plate Voltage Batteries.

World Radio History

operator's hands while manipulating the tuning controls.

It is thought to be an expensive, or at least difficult mechanical job, to properly shield the rear of an amateur receiving set panel, and it is, without proper tools, when using a copper plate shield.

The writer recently overcame the high cost and difficulty of construction of such a shield by a remarkably simple process, and at a cost of twenty cents for a panel of twelve inches by eighteen inches, and the results are all that can be expected even from a standard navy shield.

The first step is to cover the rear of the panel with a thin coat of shellac, thinned down with wood alcohol. A book of aluminum leaf, such as used by sign painters, is then procured at a paint store, and while the shellac is very "tacky" or sticky, lay the leaf on the panel, sheet by sheet, in such a way as to completely cover the entire surface. It will surprise you to see what a perfect coating will result, the aluminum leaf lying on the panel like plating on metal.

Allow the panel to set overnight and rub lightly the following day with a soft cloth, to remove all surplus aluminum. The holes are

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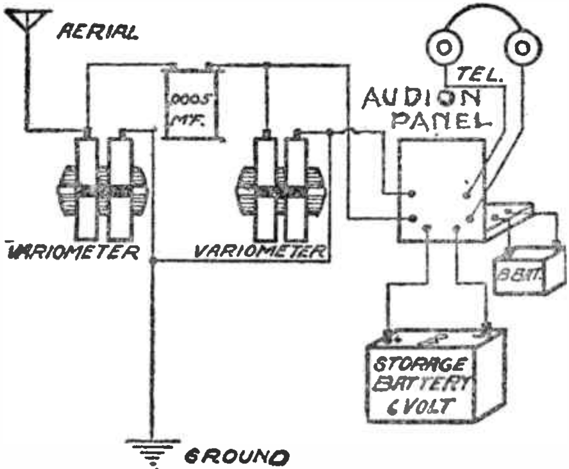
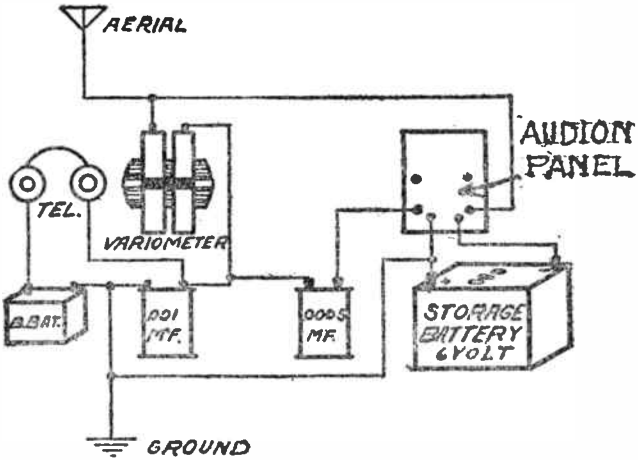


Regenerative Hook-Up Using Two Variometers



Non-Regenerative Hook-Up Using Variometer as Tuner.

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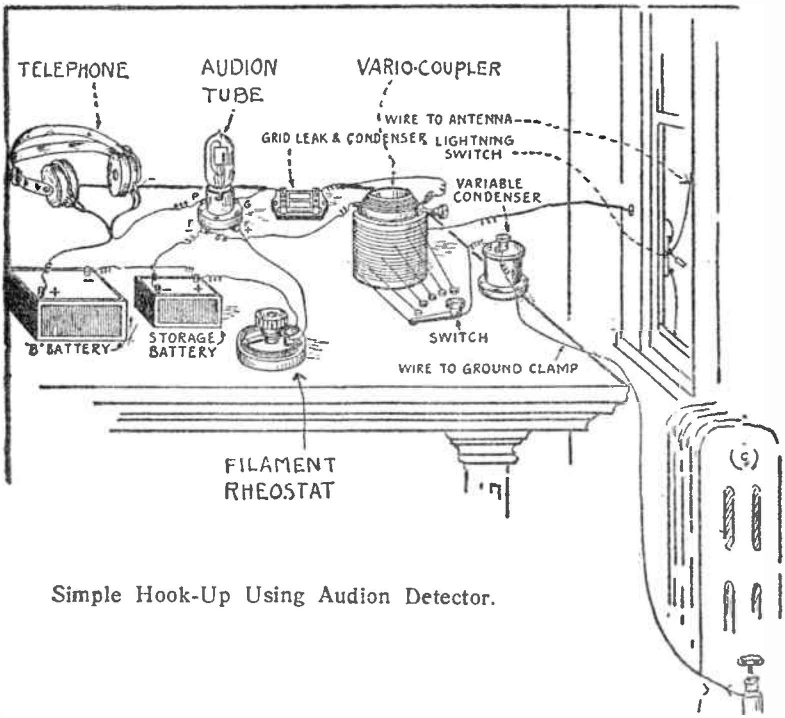

Simple Hook-Up Using Audion Detector.

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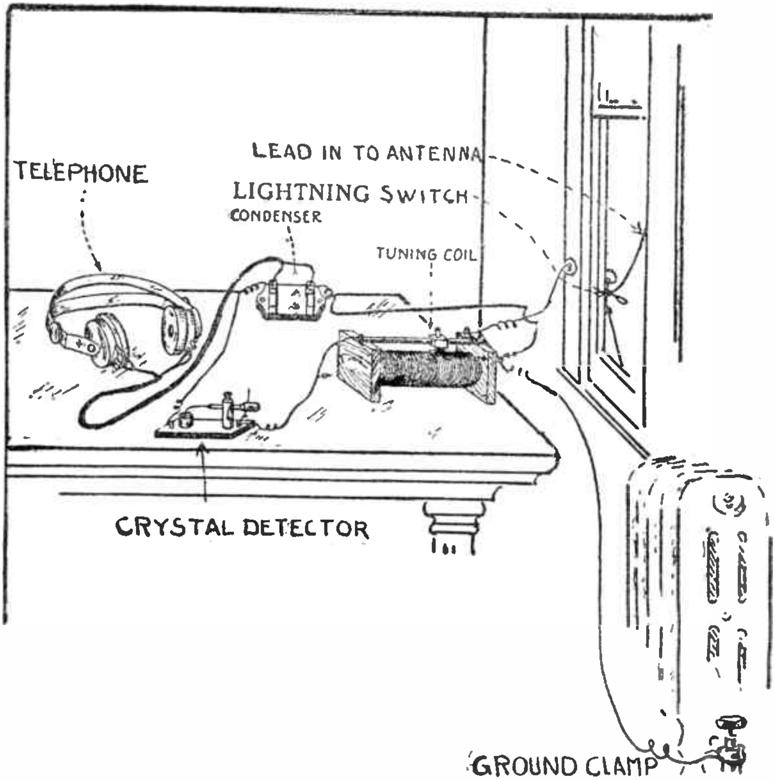

Very Simple Hook-Up Using Crystal Detector and Tuning Coil.

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then drilled in the panel and where they come through the leaf, it is scraped away so as not to form contact with any part of the circuits. The coating is grounded to the earth post of the receiver. The interior of the receiving cabinet may also be coated in the same way, making a complete metal housing about the receiver. Should the very highest conductivity be desired, silver leaf may be used, but aluminum is very satisfactory.

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CHAPTER XVII

AUDIO AND RADIO FREQUENCY AMPLIFICATION

Difference Between "A.F.A." and "R.F.A."—The Uses of Each

IT is a mistake to think that you can get satisfactory results from your loud speaker with a crystal radiophone receiver.

Loud speakers cannot be operated well unless you have an audion with one or two steps of audion amplification. With two steps of amplification signals were heard by a friend of mine three blocks away from his instruments with the windows shut.

Two kinds of amplification are in common use at the present time—radio frequency amplification and audio frequency amplification. With the first system the signals are amplified first and detected afterwards. With the second the signals are picked up first and then amplified.

The first system has only been used exten-

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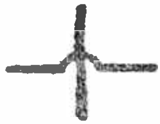
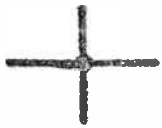
RADIO SYMBOLS

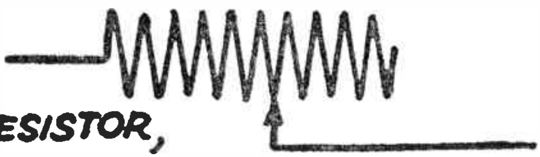


CROSSED WIRES, (NOT JOINED)



JOINED WIRES

RESISTANCE



RESISTOR, VARIABLE

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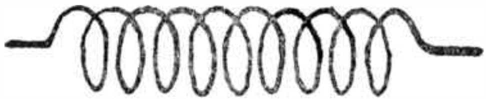
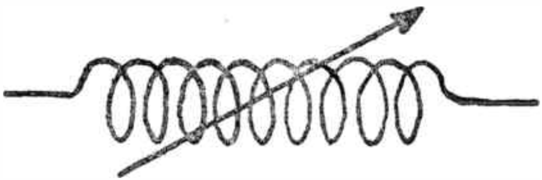
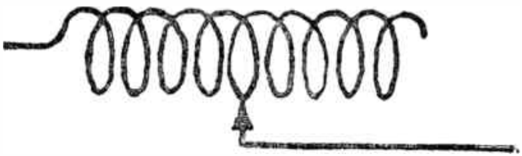
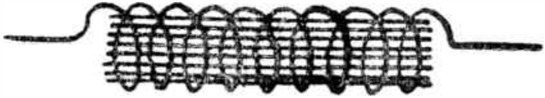


INDUCTANCE

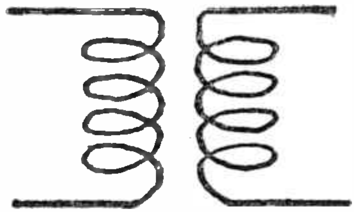




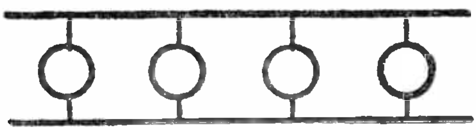
INDUCTOR, VARIABLE OR ADJUSTABLE



INDUCTANCE, IRON CORE

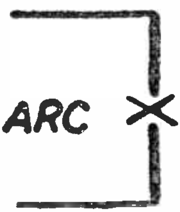


MUTUAL INDUCTANCE, OR INDUCTIVE COUPLER



LAMP BANK

ARC



ANTENNA

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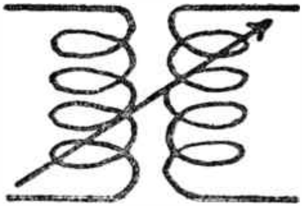
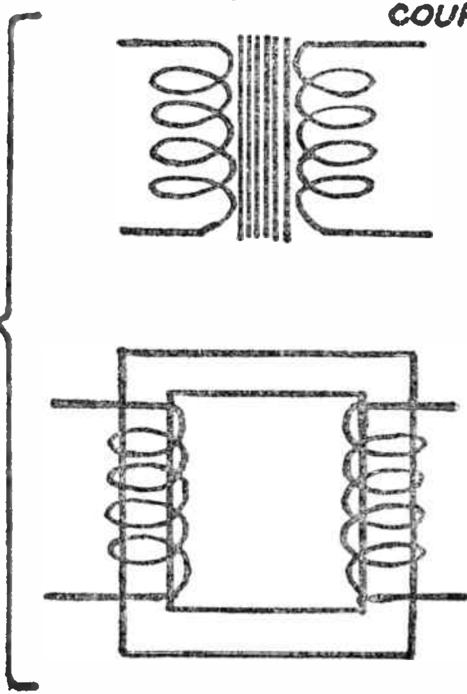


INDUCTIVE COUPLER, WITH VARIABLE COUPLING



TRANSFORMER

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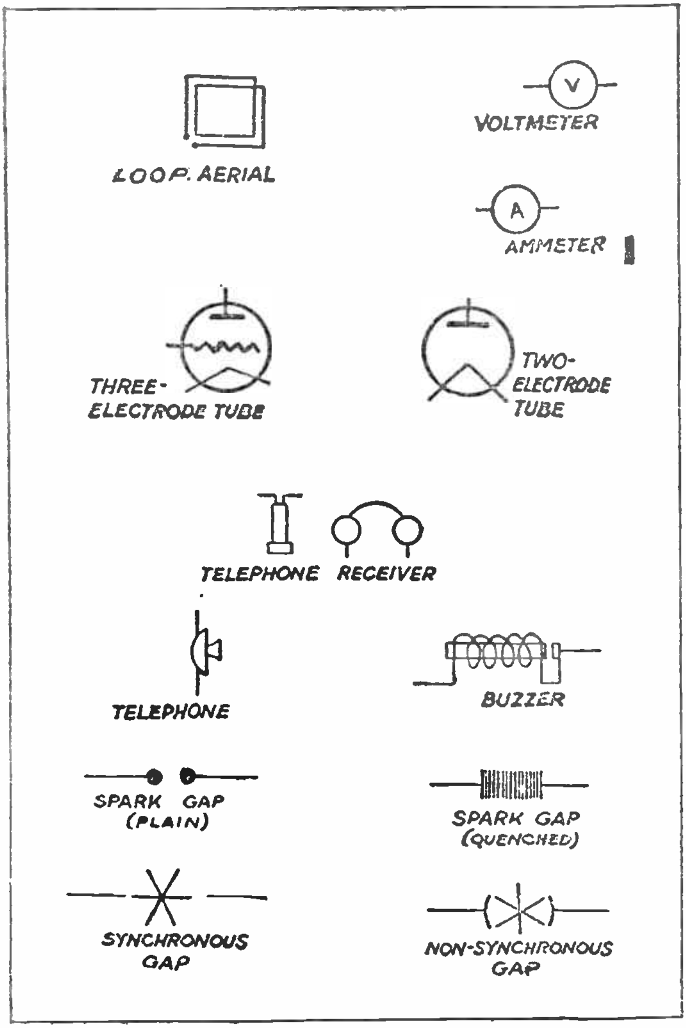

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sively in amateur radio work during the last few months. With it you can use two to six steps without distortion of signals or the howling of bulbs. Faint signals can be amplified with this system which never would be heard with the audio frequency amplifiers.

It must be remembered that with audio frequency amplifiers, if more than two steps are used, everything will be amplified but what you want. Instead of getting music you will get the arc light four blocks away making a noise like Niagara; somebody's flivver passing down the street roaring like the Twentieth Century Limited; the door bell behaving like a fire alarm. If you had radio frequency amplifiers these undesirable noises would be practically unamplified.

With the radio frequency amplifiers you must use a different type of amplifying transformer, and the method of connecting up the amplifier circuit is of quite another kind than that used when operating an audion frequency amplifier. Your dealer will explain to you the differences if you should decide to install the more efficient kind.

Radio frequency amplification, as you see, offers unusual advantages in receiving radio signals of all types, especially radiophone or

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modulated waves, over all other known methods of receiving. The use of audio amplification is familiar to operators, and is known to be limited. A signal which is too weak to operate the detector tube can never be amplified by audio amplification, regardless of the number of stages used. After the signal is strong enough to operate the detector, audio amplification is effective up to two stages. Audio amplification, beyond this, is limited by distortion and inherent audio tube noises.

By radio amplification the original weak incoming signal is raised to a value for effective operation of the detector tube. Regardless of how weak the signal is to start with, a proper radio amplification will bring it up to sufficient strength to make the detector function, after which audio amplification may be applied. Stations which are normally beyond range can, therefore, easily be brought in by using radio amplification.

By using a correct radio transformer the incoming signal frequency is amplified without the accompanying tube noises and local sounds, since the transformer will not respond to low frequency or audio sounds. Jarring

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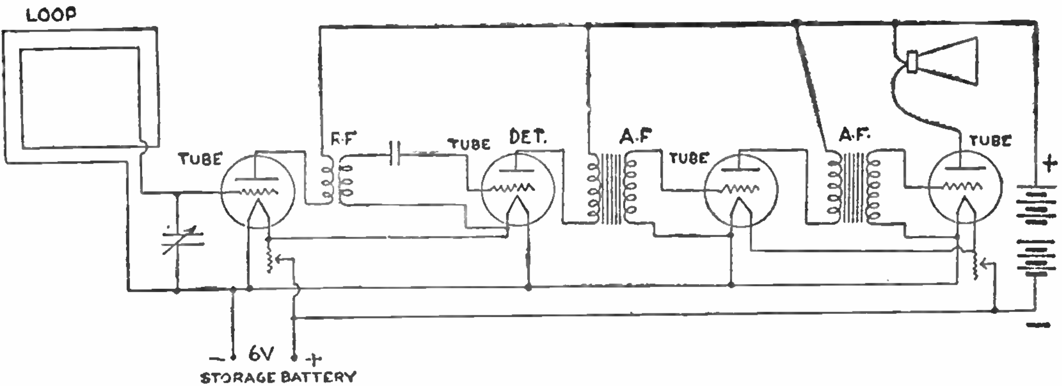

Connection for a Receiver Using a Loop as an Aerial, One-Step of Radio Frequency Amplification, and Two Steps of Audio Frequency.

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the tubes, etc., will, therefore, not produce a ringing sound or disturb the receiver in any way, as with audio, nor limit the number of stages or radio amplification which the operator desires to use.

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CHAPTER XVIII

CONDENSERS

How Condensers Assist in Tuning—Fixed and Variable Condensers

CONDENSERS are very important parts of a receiving set. Without them we could not tune sharply. Condensers in their simplest forms or the kind used in practically all small amateur receiving sets consist of a series of wax paper sheets coated on one side with tin foil. These sheets are laid club sandwichwise, a sheet of tin foil, a sheet of wax paper and then a sheet of tin foil again until there are, say a layer of seven pieces of paper and six of tin foil. Half the sheets of tin foil are connected to one wire and the other half to another wire, these two wires forming the terminals of the condenser.

Condensers have the property of accumulating electrical energy and suddenly discharging it and while very essential they are usually overlooked and unknown to some radio-

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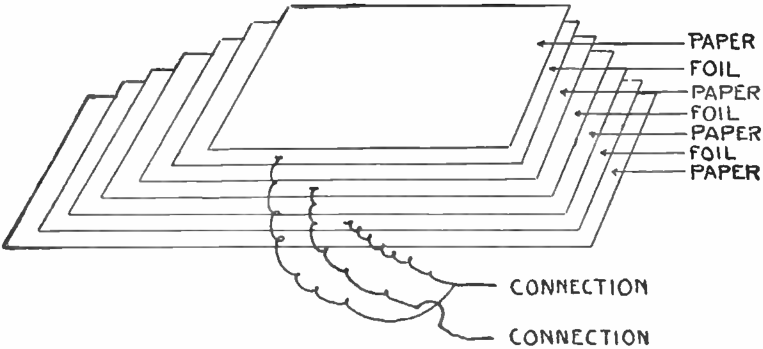
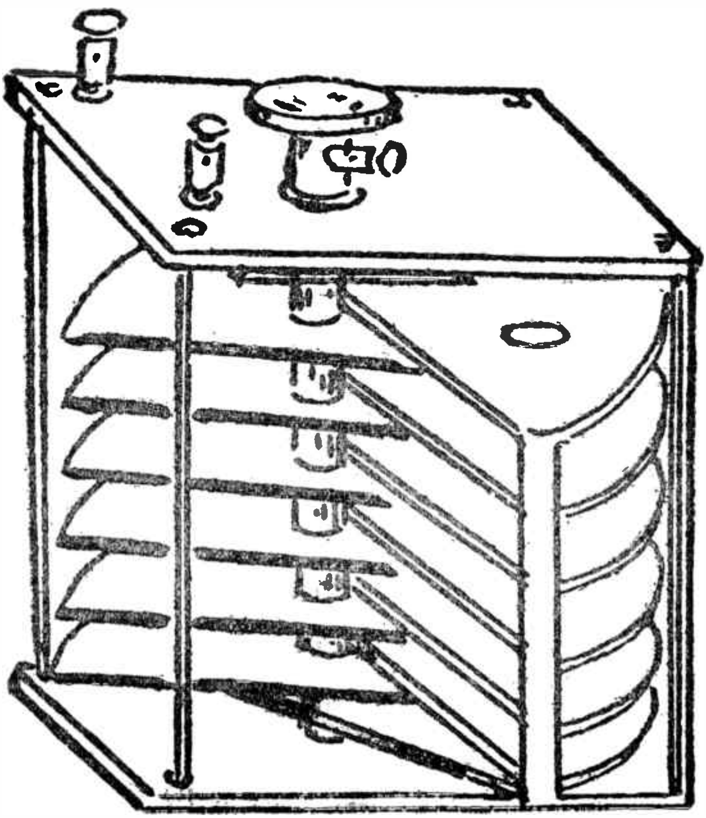


Diagram Showing Construction of Fixed Condenser.



Variable Condenser.

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phone fans, as they are usually hidden away in the back of the receiving set in an inconspicuous place.

Another form of receiving condenser consists of a number of half circular plates so placed that they may be rotated or moved past a series of fixed semi-circular plates. The plates do *not* touch as the space between them takes the place of the paraffin paper in the previously mentioned type.

The rotating semi-circular plates are mounted on a shaft and attached to a knob so that the condenser may be adjusted at will to any capacity desired.

Variable condensers are capable of being adjusted more finely than regular tuning coils or loose couplers for the changes brought about by varying the positions of the plates are very gradual. In a tuning coil or loose coupler the tuning must naturally be very rough.

Experimental radio receiving sets require condensers whose quality is high and whose price is reasonable. It is easy to manufacture low-priced condensers as is evidenced by the large number now available. It is more difficult, however, to construct a condenser which is electrically and mechanically good,

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and yet at the same time keep the cost of construction low.

The value of a good condenser in a receiving set is not always fully appreciated. The dielectric losses of the condenser are equivalent to adding a series resistance in the oscillating circuit. To add a series resistance in the oscillating circuit means loss of energy which, in turn, means broad tuning and diminished signal strength. It is thus important that the dielectric losses in condensers be kept low.

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CHAPTER XIX

TUNING AND INTERFERENCE

Proper Method of Operation of Audion Set—How to Avoid Interference, or Q.R.M.—Way to Find the Desired Wave-Length—Meaning of Resonance Between Transmitter and Receiver

QUITE a few amateurs are puzzled after they have installed their sets as to how they should tune-in for desired signals. They find that, try as they may to get the music, they succeed in getting nothing but cryptic and otherwise, to them, unintelligible sounds from the big commercial spark stations.

I've often heard people who had just installed perhaps a $150 set exclaim:

"Whatever you do don't buy one of these sets. I've fooled with it for two hours or more and can't get anything but faint signals."

Read the following closely and you will never be troubled in this way. To tune a receiving set that incorporates a loose coupler as the main tuning device set the coupling as tight as you can possibly get it, tune in the de-

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sired signals with the primary or outside inductance, and then tune in with the secondary or inner inductance until you have the greatest strength of signals.

Loosen the coupling between the primary and the secondary until the signals are just audible. Retune with the primary and the secondary until the signals are the strongest at the present setting of the coupling. Finally tighten the coupling until you get the maximum clarity. This method of tuning with the loose coupler is the only right way, and when the signal is tuned in in this manner there will be a minimum of interference, or "Q.R.M."

With a regenerative receiver, having a vario-coupler, plate variometer and grid variometer the proper method of tuning in desired signals is as follows:

First set the coupling of the vario-coupler at maximum degree, or, in other words, the primary and secondary are as near together as possible. Tune with the switch knob on both the primary and secondary, then tune with the grid variometer until the greatest signal strength is obtained. The plate variometer, which should have been set at zero, while tuning the primary and secondary of the vario-

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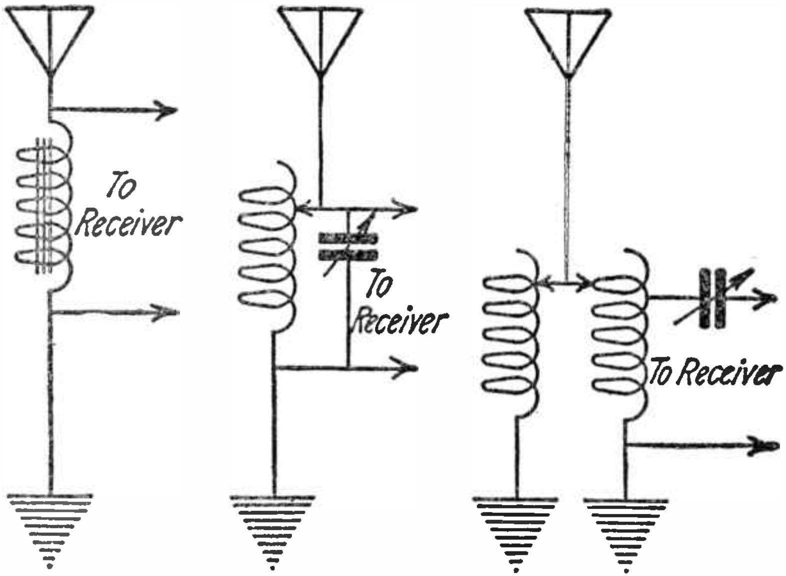

(c) 1922 by Radio News
Methods of Reducing Induction "Hum" from Nearby Power Lines.

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coupler and the grid variometer, is now moved slowly until you get greatest signal strength without distortion.

If you desire to tune in radiotelephone music you should set the plate variometer well past the oscillating point. Then tune with the vario-coupler to the wave-length the music is being transmitted on.

The grid variometer is varied slowly until a loud "squeal" is heard in the phones. You will notice that this squeal starts at a very high frequency, and as you continue to turn the knob it slows down until it reaches an inaudible point, then increases in frequency again to the point where it is inaudible, or above 10,000 cycles.

At the point where no sound is heard between the two howls is the spot you should hear the music or voice, and if by any chance you do not hear anything wait a minute or two before you commence tuning again, for the station may not be talking at the moment.

The coupling between the primary and the secondary of the vario-coupler is preferably left at maximum; as in most sets, the coupling does not make very much difference. Try it out and see what it does on your set.

All this may sound complicated and "deep

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stuff" to the novice, but after a trial or two you will see how easy it is. *Always remember to tune with the grid-variometer first, then regenerate the signals with the plate variometer. Be sure to have your audion lighted brightly enough to enable it to oscillate.*

Tuning of the receiving to the beginner is a thing that has a lot of mystery connected with it. The question has been asked, "How do you know where to pick up the desired signal?" There is no way to tell on a set that the amateur is not familiar with. But, after the set has been in operation for a little while, the beginner will soon learn exactly where to pick up the desired signals.

Most sets have dials on them that are divided off into 180 degrees with the numbers engraved on them for every ten degrees. These numbers have nothing whatsoever to do with the wave-length of the station, but are simply put there to enable the operator to remember easily at what point a station will be heard. Usually the lower numbers represent the short wave lengths and as the dial is turned about the longer waves will be heard.

With most sets it is a very simple matter to soon learn exactly where the desired signal may be heard, and the set may be left in the

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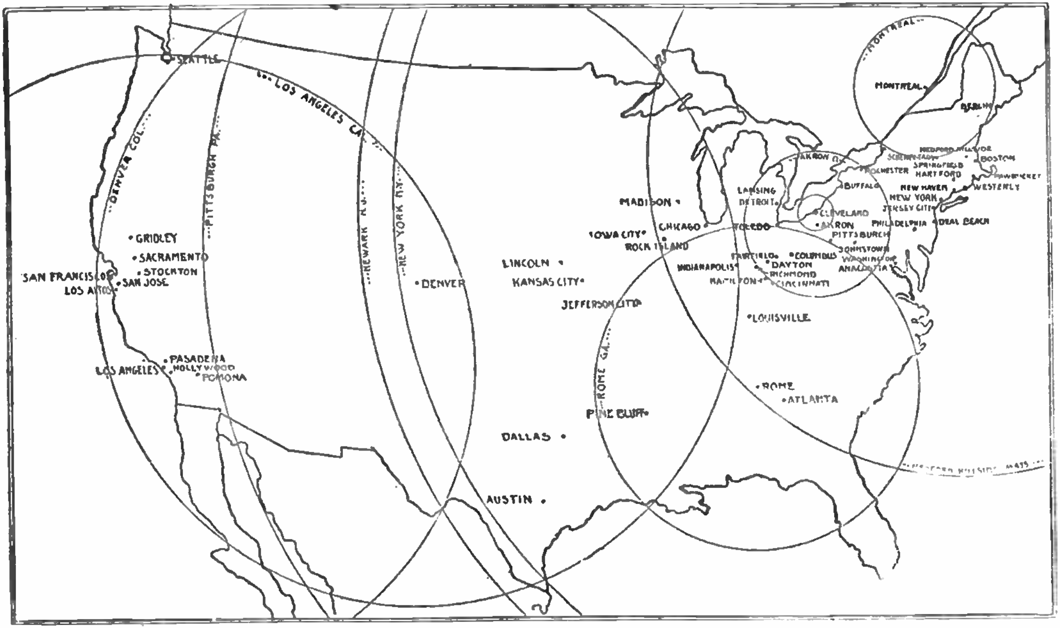

Map Showing the Most Important Broadcasting Stations in the United States. The Circles Show the Potential Range of the Transmitting Stations.

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same setting all the time if it is used just for receiving the broadcasting. In other words, the set is tuned to receive the music from your pet broadcasting station and there is no necessity to move the knobs again unless other stations are wanted.

The theory of tuning is a long and complicated study, and a few words on the subject may clear up a lot of misinformation. In the first place, every transmitting station has a certain wave-length upon which the transmitted signals or voice is transmitted. The receiving set, however, is capable of receiving several wave-lengths by tuning the knobs about. A transmitter can also be made to transmit on several wave-lengths, but cannot be tuned as fast as receiver.

When your receiving set is tuned to receive a certain transmitting set it is in resonance with the other station. A simple way to explain this is to say that the wave lengths are very nearly the same. This is accomplished by adding or subtracting a certain number of turns of wire in the coils and thus equalizing the wave-lengths of the two stations. By the addition of different pieces of apparatus it is possible to make this tuning very sharp, and there are some sets that will receive the de-

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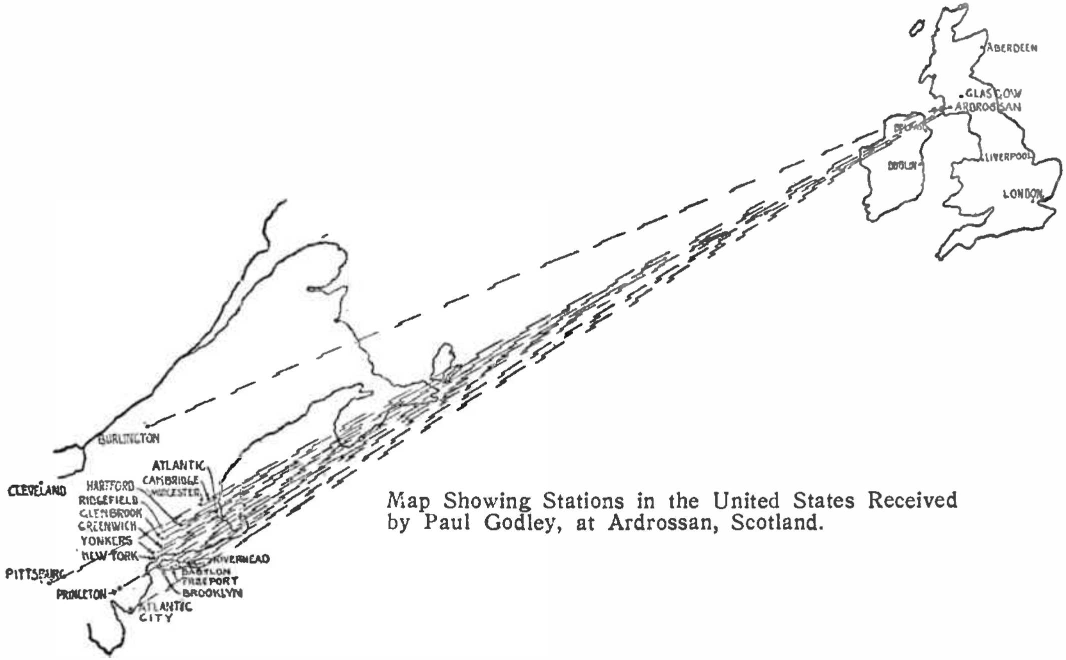

Map Showing Stations in the United States Received by Paul Godley, at Ardrossan, Scotland.

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sired signals only. However, these sets are very expensive and the operator has to be an expert. The average amateur set will not tune sharp and a great deal of trouble has been caused by some beginners filing complaints about some amateur spark transmitter. Usually the spark transmitter is tuned to a sharp wave and is operating legally, while the beginner's set is the one that is at fault, as it is incapable of sharp tuning. If more beginners would study up on these facts before purchasing a set there would not be so much interference. Many amateurs have home-made receiving sets with which it is possible to sit and listen to their favorite programs all the evening without hearing a single interfering station.

Of course there are certain cases where it is impossible to tune out the unwanted station with any set. Some amateurs are unfortunate enough to be located very near one of the naval or ship stations, and it is impossible to do any tuning, owing to the close proximity of the transmitter. When buying a set ask for a demonstration showing the selectivity of the set, as by doing this the beginner will save himself a great deal of trouble in the future.

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CHAPTER XX

A PERSONAL EXPERIENCE

How a First Step of Amplification Acted as a Detector, and the Second Step as a One-Step Amplifier and Oscillator—Visiting the "Other Fellow's" Station

LET me here refer to a personal experience. While enjoying the music on a friend's new receiving set with a two-step amplifier, one evening, I noticed when I turned the detector tube out and left the two steps of amplification burning, that strong continuous wave signals still came in.

After keeping my ears glued to the phones for about fifteen minutes, during which time I heard some of the best sending I had ever listened to, to my surprise the station signed "WSO." This is the Radio Corporation of America's station at Chatham, Mass., which was working Stavanger, Norway, whose call is LCM! The amateur station I was visiting is at Asbury Park, N. J.

The receiving set was a short wave one, and no adjustment that I made seemed to change

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the strength of the signals, except when I turned the filaments lower or brighter on the two-step. *The first step of amplification was working as a detector, and the second step of amplification as a one-step.*

So I then connected the antenna and ground to the primary of the amplifying transformer of the first step, and many long distance stations came in, including NSS, NBA, NAT, NAU and BZR which are, respectively, Annapolis, Darien, (Panama), New Orleans, San Juan, (Porto Rico) and Bermuda. Needing a way to tune, I connected a variable condenser in series with the antenna which enabled me to tune NSS entirely out and tune NAT in.

Another thing I noticed was that when the filament current of either tube was increased or decreased, some of the stations would come in louder than others, and tuning could be done with the filaments of the tubes.

All the time that I was copying these stations there was a high pitched whistling in the telephones, probably due to the close proximity of the amplifying transformers.

To the real radio enthusiast the other fellow's station is always a source of interest.

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This is not surprising when one considers the number of possible variations in the arrangement of the essential apparatus, to say nothing of the numerous original devices beloved of the amateur.

Apart from those whose interest is transitory, and who have nothing more than a radiophone receiver which they have acquired simply because they think it is the thing to possess one; and apart from those who buy expensive self-contained sets in the fond but seldom realized hope that without any skill on their part they will be able to delight their friends with wireless music, via loud speaker (with only a frame aerial about as large as an electric toaster) one may divide radio amateurs into two classes—experimentalists and operators.

In the first class we have those whose chief delight is in designing and making some new piece of apparatus or re-arranging existing apparatus with a view to greater effectiveness. In many cases they cannot even read the code. But, incidentally, you may have noticed that this does not prevent them from talking glibly of the Eiffel Tower or Honolulu, as though they were old pals.

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The other class consists of those whose chief delight is to intercept messages, and who judge of the efficiency of their station not by the noise it makes when, say the music starts up but by the long distance traffic it enables them to copy.

Of course, there are many in this class who do their share of experimenting also; but as this is principally to improve the receiving range, it does not affect the classification.

A glimpse at the other fellow's station is generally sufficient to enable one to say to which class he belongs. The experimentalist's set is never finished, invariably looks like a junk heap, and needs a lot of persuasion before it can be coaxed into articulation.

It never is doing as well when you happen to be there as it did last Wednesday week when,

"Gee, you should have heard the signals the other night when 'Loose-Coupler Abe' was here. They nearly broke your ear drums two blocks away."

The storage battery is run down, or perhaps the slider on the inductance has sprung a leak. There's never any lack of excuses for its backsliding.

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On the other hand, the keen operator maintains his set at concert pitch seven days a week, ready at all times to respond to any of the old favorites whose tuning adjustments he knows to a degree.

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CHAPTER XXI

STORAGE BATTERIES

Accumulators Necessary for Radio Receivers—How Batteries are Rated—Testing and Charging Batteries

IT is impossible to properly light a vacuum tube detector or amplifier unless a storage battery is used. Dry cells are no good for the purpose.

The reason is that the average vacuum tube draws about one ampere per hour, and with such a strain on it a dry cell will last but a short time, when it will have to be replaced. With the price of these cells at their present high level it is poor economy to do this, as you will have to buy a new set of six cells about every week if the receiving set is used very much. The storage battery, on the other hand, has a much longer life, and when it becomes low it may easily be charged up again at almost any garage.

In order that you may understand something about a battery before you buy it it will

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be well to remember that storage batteries are rated by the number of volts that they will give and the number of ampere hours the battery will be able to deliver this voltage. You will find that there are many different kinds of ratings on storage batteries. These ratings are given in ampere hours, and run from 10 ampere hours upward. The thing that is desirable is to have this rating as high as possible, as the whole meaning of the term is that the battery will deliver one ampere for so many hours, hence the saying, "this cell has sixty ampere hours." When you hear that you will know that that particular battery will give one ampere continuously for sixty hours.

When you use this battery with a vacuum tube that draws one ampere it will light the filament for about sixty hours. Now, suppose you put on one step of amplification, or another bulb. This bulb will also draw one ampere, making a total of two amperes that are drawn from the battery. This will exactly halve the number of hours the storage battery will last before it has to be recharged, or only thirty hours. The addition of another amplifier will cut it still lower, as you will draw three amperes from the battery. This will leave you only twenty hours of life from a

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storage battery that will give sixty ampere hours. As you will never use the battery for the full sixty or twenty hours continuously it will really last longer, as the battery has a tendency to recuperate during the time that it is not in use. Of course it will never come back to full capacity, but there will be a slight rise. Never let the battery get fully discharged or even low, because it is bad for it, and, in time, will ruin it entirely.

There are many ways of testing batteries and among them you will hear of the trick of snapping a piece of wire across the terminals. There is nothing that will ruin a battery quicker than this. Another way is to connect a voltmeter across the lugs. A cell of the battery may become nearly exhausted, yet it will show its full voltage with this method and it is absolutely useless. A small ammeter will "go up in smoke" if you try using one, so don't do that. The only sure way to test a storage battery is to get a hydrometer.

A storage battery may be ruined by having an overcharge as well as being allowed to stand discharged. They must be taken care of if you want them to last. For radio work a battery should not have over six volts and the easiest way to tell this is to look at the

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number of little vent caps on the top. Each of these caps takes care of one cell and each cell is good for two volts.

Here are some tips on rectifiers for charging storage batteries: The lamp used for the charger should be a carbon lamp and the more lamps added the higher the amperage will be that is passed. This will make the battery charge up quicker, but the rate should not be over five amperes. If the battery is charged too fast it is apt to spoil the plates.

The plates do not have to be formed but once, before the first charge, but every time new aluminum plates are put in they will have to be reformed. The rectifier will work well if enough amperage is passed and the lights are added to make the amperage high. If it is too low the battery will not charge up properly. The rectifier cannot be used to light the filaments direct, and the amateur is advised not to do this as it will surely burn them out. The rectifiers will run warm in time and more water will have to be added as it evaporates. Do not add any more borax.

If the rectifiers boil and get too hot it is a sign that too much amperage is being passed or that it is not connected up correctly. The whole secret of charging the battery is to have

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the charging rate correct, and to do this it is necessary to experiment as some batteries require a higher rate than others. The length of time required to charge a battery is also dependent on the number of amperes that are being passed, that is the lower the amperage the longer the charge will take. Do not think that the battery can be charged up in three or four hours, because this cannot be done. It will require at least twenty-four hours, if the battery is all the way discharged. By getting a hydrometer a sure method of testing the battery can easily be accomplished. Full directions come with every instrument.

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RADIO GLOSSARY

A.C.—Alternating Current.

Ampere—The practical unit of electric current strength; such a current as would be given with an electromotive force of one volt through a wire having a resistance of one ohm.

Aerial—The wires suspended on the roof of a building that are used for receiving or transmitting. A single wire aerial is all that is needed for receiving.

Antenna—This term means the whole aerial and ground system.

B Battery—A small dry battery that is used in a vacuum tube circuit only. It is built so that a high voltage is given which is necessary for the operation of the tube. Some of the batteries are arranged in such a way that the voltage may be varied.

Current—The amount of electricity passing a given point in unit time, measured in amperes.

C.W.—Continuous Wave.

D.C.—Direct Current.

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Detector—The device, either crystal or vacuum tube, that is used to detect the incoming waves and rectify them so that they may be made understandable.

Electromotive Force (E.M.F.)—The term applied to electric pressure, measured in volts.

Grid—A zinc plate in a storage battery or a lead plate for retaining the active material in a storage battery, or a zig-zag coil of wire, between the plate and filament in an audion tube.

Ground—The opposite end of the aerial circuit. It usually consists of a wire connected to the cold-water pipe. It is also used for connecting the lighting arrester to. If used for the latter purpose it should be an outdoor ground and many consist of a pipe driven deep into the ground or any buried metal.

Honeycomb Coils—A type of coil that may be plugged into a special fitting. Different sized coils are used for different wave lengths. Duo lateral coils are about the same thing. Both are very efficient for long wave reception.

Induction—The process by which a magnetizable body becomes itself electrified in the presence of an electrically charged body or a magnetic field electrically produced.

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Loop Aerial—A form of indoor aerial and direction finder. Usually wound on a form about five feet in diameter. Cannot be used with a crystal detector and works best only with several stages of amplification. Not as efficient as the outside aerial and not recommended for the beginner.

Loose Coupler—A form of tuning coil that is a little more efficient than the plain tuning coil. It enables the operator to "loosely couple" the set and thereby eliminate a lot of interference.

Loading Coil—A large single slide tuning coil that is used to load a receiving set up to longer wave lengths. Not a very efficient form of tuning.

Microphone—An instrument for magnifying faint sounds by the variation in electrical resistance caused by variation of pressure at a loose contact.

Oscillation—A high-frequency electric current, the maximum value of which constantly diminishes, with a speed depending on the damping effect present. Frequently linked in radio theory with the Herzian Waves, the basic radio conception, which deals with the wave propagation of electro-

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magnetic induction, the underlying principle, of course, of wireless communication.

Ohm—The unit of electrical resistance; concretely represented by the resistance of 400 feet of common iron telegraph wire.

Rheostat—An instrument by which a variable or adjustable resistance may be introduced into a circuit to regulate the strength of the current.

Resistance—The opposition to the flow of current shown by every direct current (D.C.) circuit, measured in ohms.

Spider Web Coils—A form of tuning coil wound similar to a spider web. They are also called stagger wound inductances. Very efficient for a regenerative set.

Tuning Coil—Usually either a double slide or triple slide. The difference in efficiency is very small. A cylindrical coil of wire upon which a sliding contact is made with the aid of a special slider. This varies the wavelength of the set and tunes it to the incoming signal.

U.D.—Undamped, or Continuous Wave.

Vacuum Tube or Audion Bulb—A form of detector making use of the electronic theory. Most efficient form of detector. Certain

World Radio History

forms of the tube may be used for amplifiers and others for transmission. This type of tube used exclusively for transmission of speech and music.

Variometer—Will help to tune the set using a variocoupler. Also may be connected into the circuit of a crystal detector that will give good results.

Variocoupler—Still another form of tuning unit. It will tune about the same as a loose coupler. Very efficient in a set using a vacuum tube if connected in with two variometers.

Volt—The practical unit of electromotive force; such a force as would carry one ampere of current against one ohm of resistance.

Variable Condenser—The instrument that consists of a series of aluminum plates, half of which are stationary and the other half movable. It is used to vary the capacity of the set and will greatly help the tuning.

Wave Length—The distance between the crests of each wave or series of wave trains measured usually in meters.

Wave Train Frequency—The number of wave trains or groups of wave trains radiated per second by transmitter antenna.

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Watts—The units by which power is measured. In D.C. Circuits the voltage multiplied by the amperes flowing in the circuit gives watts. A watt is equal to 1-746 horsepower.

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ARLINGTON WEATHER REPORT. 2,500 Meters, Call Letters, N. A. A.

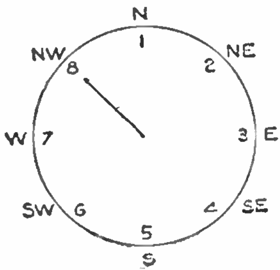
Sample Report: QSTdeNAA, USWB, S01081—T02261 DB 0251—H 00844—G 01261—K 00441—P 01242

QST—General call.
de—From
NAA—Arlington Station
USWB—U. S. Weather Bureau

"010"—30.10 inches, Barometer
"8"—Direction of wind
"1"—Velocity of wind

Du—Duluth
D—Detroit
Ch—Chicago
U—S. S. Marie
G—Green Bay
M—Marquette
V—Cleveland
L—Alpena
F—Buffalo
K—Key West, Fla.
S—Sidney, Nova Scotia.
T—Nantucket, R. I.
DB—Delaware Breakwater.
H—Cape Hatteras, N. C.
C—Charleston, S. C.
P—Pensacola, Fla.
B—Bermuda.

Direction of Wind —O Calm



Report is for conditions at 8 P. M. of the day sent out from Arlington. It is sent out 10 P. M.

Beauford Wind Intensity Scale

		Statute M.P.H.
0	Calm	0—3
1	Light Air	8
2	Light Breezes	13
3	Gentle Breezes	18
4	Moderate Breezes	23
5	Fresh Breezes	28
6	Strong Breezes	34
7	Moderate Gale	40
8	Fresh Gale	48
9	Strong Gale	56
10	Whole Gale	65
11	Storm	75
12	Hurricane	90

Statute Miles per Hr:—1.15. Nautical—M. P. H.

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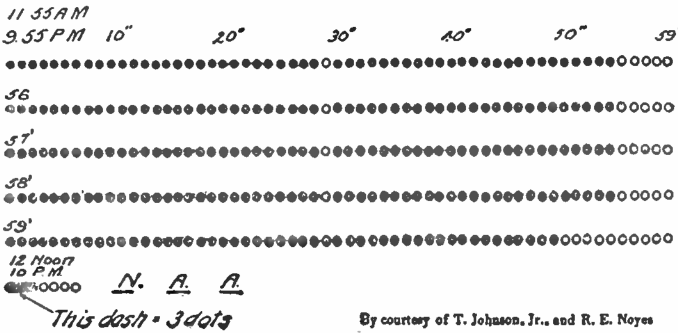
ARLINGTON—TIME SIGNAL—
2500 METERS

Note. The Arlington Station sends time signals on a wave length of 2500 meters commencing at 11:55 A. M. and 9:55 P. M. *every day*. Final signals at 12 Noon and 10 P. M. are for the meridian of 75 degrees west of Greenwich. Every tick of the standard clock at the Naval Observatory, Washington, is transmitted as a dot, omitting the 29th second of each minute, the last five seconds of each of the first four minutes and finally the last ten seconds of the last minute. The 12 Noon and 10 P. M. signal is dash.



By courtesy of T. Johnson, Jr., and R. E. Noyes

World Radio History

U. S. RADIO LAWS AND REGULATIONS

The owner of any amateur radio transmitting station must obtain a station license before it can be operated. These regulations cover the operation of radio-telephone stations as well as radio-telegraph stations.

Station licenses can be issued only to citizens of the United States, its territories and dependencies.

Transmitting stations must be operated under the supervision of a person holding an *Operator's License* and the party in whose name the station is licensed is responsible for its activities.

The Government licenses granted for amateur stations are divided into three classes as follows:

Special Amateur Stations known as the "Z" class of stations are usually permitted to transmit on wave lengths up to approximately 375 meters.

World Radio History

DEPARTMENT OF COMMERCE
RADIO SERVICE

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A	• —
B	— • • •
C	— • — •
D	— • •
E	•
F	• • — •
G	— — •
H	• • • •
I	• •
J	• — — —
K	— • —
L	• — • •
M	— —
N	— •
O	— — —
P	• — — •
Q	— — • —
R	• — •
S	• • •
T	—
U	• • —
V	• • • —
W	• — —
X	— • • —
Y	— • — —
Z	— — • •
Ä (German)	• — • —
Á or Å (Spanish-Scandinavian)	• — — • —
CH (German-Spanish)	— — — —
É (French)	• • — • •
Ñ (Spanish)	— — • — —
Ö (German)	— — — •
Ü (German)	• • — —
1	• — — — —
2	• • — — —
3	• • • — —
4	• • • • —
5	• • • • •
6	— • • • •
7	— — • • •
8	— — — • •
9	— — — — •
0	— — — — —

Period	• • • • • •
Semicolon	— • — • — •
Comma	• — • — • —
Colon	— — — • • •
Interrogation	• • — — • •
Exclamation point	— — • • — —
Apostrophe	• — — — — •
Hyphen	— • • • • —
Bar indicating fraction	— • • — •
Parenthesis	— • — — • —
Inverted commas	• — • • — •
Underline	• • — — • —
Double dash	— • • • —
Distress Call	• • • — — — • • •
Attention call to precede every transmission	— • — • —
General inquiry call	— • — • — — • —
From (de)	— • • •
Invitation to transmit (go ahead)	— • —
Warning—high power	— — • • — —
Question (please repeat after ... ..)—interrupting long messages	• • — — • •
Wait	• — • • •
Break (Bk.) (double dash)	— • • • —
Understand	• • • — •
Error	• • • • • • • •
Received (O. K.)	• — •
Position report (to precede all position messages)	— • — •
End of each message (cross)	• — • — •
Transmission finished (end of work) (conclusion of correspondence)	• • • — • —

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General Amateur Stations which are permitted to use a power input of 1 kilowatt and which cannot use a wave length in excess of 200 meters.

Restricted Amateur Stations are those located within five nautical miles of Naval radio stations, and are restricted to ½ kilowatt input. These stations also cannot transmit on wave lengths in excess of 200 meters.

Experimental stations, known as the "X" class, and school and university radio stations, known as the "Y" class, are usually allowed greater power and also allowed the use of longer wave lengths at the discretion of the *Department of Commerce.*

All stations are required to use the minimum amount of power necessary to carry on successful communication. This means that while an amateur station is permitted to use, when the circumstances require, an input of 1 kilowatt, this input should be reduced or other means provided for lowering the antenna energy when communicating with nearby stations in which case full power is not required.

Malicious or wilful interference on the part of any radio station, or the transmission of any false or fraudulent distress signal or call is

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prohibited. Severe penalties are provided for violation of these provisions.

Special amateur stations may be licensed at the discretion of the *Secretary of Commerce* to use a longer wave length and higher power than general amateur stations. Applicants for special amateur station licenses must have had two years' experience in commercial radio communication. A special license will then be granted by the *Secretary of Commerce* only if some substantial benefit to the science of radio communication or to commerce seems probable. Special amateur station licenses are not issued where individual amusement is the chief reason for which the application is made. Special amateur stations located on or near the sea coast must be operated by a person holding a commercial license. Amateur station licenses are issued to clubs if they are incorporated, or if any member holding an amateur operator's license will accept the responsibility for the operation of the apparatus.

Applications for operator's and station licenses of all classes should be addressed to the *Radio Inspector* of the district in which the applicant or station is located. *Radio Inspectors'* offices are located at the following places:

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DEPARTMENT OF COMMERCE
BUREAU OF NAVIGATION
RADIO SERVICE

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION.	QUESTION.	ANSWER OR NOTICE.
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?...........	This is........
QRB	What is your distance?......................	My distance is........
QRC	What is your true bearing?..................	My true bearing is........degrees.
QRD	Where are you bound for?....................	I am bound for........
QRF	Where are you bound from?...................	I am bound from........
QRG	What line do you belong to?.................	I belong to the........Line.
QRH	What is your wave length in meters?..........	My wave length is........meters.
QRJ	How many words have you to send?............	I have........words to send.
QRK	How do you receive me?......................	I am receiving well.
QRL	Are you receiving badly? Shall I send 20? . . . — . for adjustment?...............	I am receiving badly. Please send 20. . . . — . for adjustment.
QRM	Are you being interfered with?..............	I am being interfered with.
QRN	Are the atmospherics strong?................	Atmospherics are very strong.
QRO	Shall I increase power?.....................	Increase power.
QRP	Shall I decrease power?.....................	Decrease power.
QRQ	Shall I send faster?........................	Send faster.
QRS	Shall I send slower?........................	Send slower.
QRT	Shall I stop sending?.......................	Stop sending.
QRU	Have you anything for me?...................	I have nothing for you.
QRV	Are you ready?..............................	I am ready. All right now.
QRW	Are you busy?...............................	I am busy (or: I am busy with......). Please do not interfere.
QRX	Shall I stand by?...........................	Stand by. I will call you when required.
QRY	When will be my turn?.......................	Your turn will be No. ....
QRZ	Are my signals weak?........................	Your signals are weak.

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QSA	Are my signals strong?........................	Your signals are strong.
QSB	Is my tone bad?........................	The tone is bad.
	Is my spark bad?........................	The spark is bad.
QSC	Is my spacing bad?........................	Your spacing is bad.
QSD	What is your time?........................	My time is........
QSF	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG	....	Transmission will be in series of 5 messages.
QSH	....	Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for........................	Collect........
QSK	Is the last radiogram canceled?........................	The last radiogram is canceled.
QSL	Did you get my receipt?........................	Please acknowledge.
QSM	What is your true course?........................	My true course is........degrees.
QSN	Are you in communication with land?........	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with........)?	I am in communication with ....(through ....).
QSP	Shall I inform........that you are calling him?	Inform........that I am calling him.
QSQ	Is........calling me?........................	You are being called by........
QSR	Will you forward the radiogram?............	I will forward the radiogram.
QST	Have you received the general call?............	General call to all stations.
QSU	Please call me when you have finished (or: at ....o'clock)?	Will call when I have finished.
QSV	Is public correspondence being handled?......	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?..........	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?..........	Decrease your spark frequency.
QSY	Shall I send on a wave length of......meters?	Let us change to the wave length of........ meters.
QSZ	....	Send each word twice. I have difficulty in receiving you.
QTA	....	Repeat the last radiogram.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

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First District . . . . Boston, Mass.
Second District . . . . New York City
Third District . . . . Baltimore, Md.
Fourth District . . . . Norfolk, Va.
Fifth District . . . . New Orleans, La.
Sixth District . . . . . . San Francisco, Cal.
Seventh District . . . . Seattle, Wash.
Eighth District . . . . Detroit, Mich.
Ninth District . . . . Chicago, Ill.
Tenth District (Alaska) . . Seattle, Wash.

No license is required for the operation of a receiving station, but all persons are required by law to maintain secrecy in regard to any messages which may be overheard.

There is no fee or charge for either an operator's license or a station license.

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LOOSE COUPLERS AND TUNING COILS

I

A LOOSE COUPLER is the familiar name for the oscillation transformer used in a receiving circuit. However, the loose coupler is something quite different from a transmitting oscillation transformer.

In a loose coupler resonance between the transmitting and receiving circuits is brought about by the utilization of a comparatively high value of capacity and a correspondingly low value of induction in the transmitting circuit, and in transposing these conditions in the receiving circuit. In order to keep the decrement or damping correspondingly low the resistance must be kept down to the minimum in the transmitting circuit. In the transmitting circuit a transformer with but a few turns of heavy strip copper is all that is needed for the reason that heavy currents are used.

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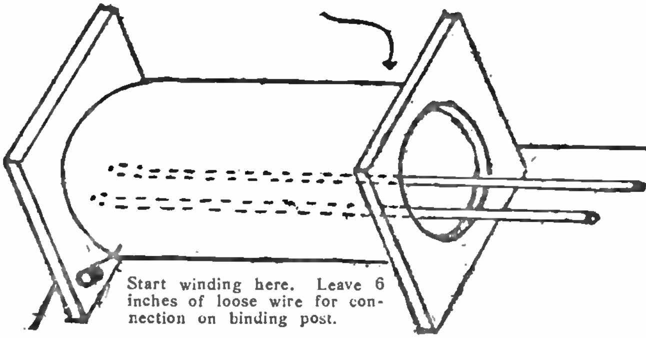
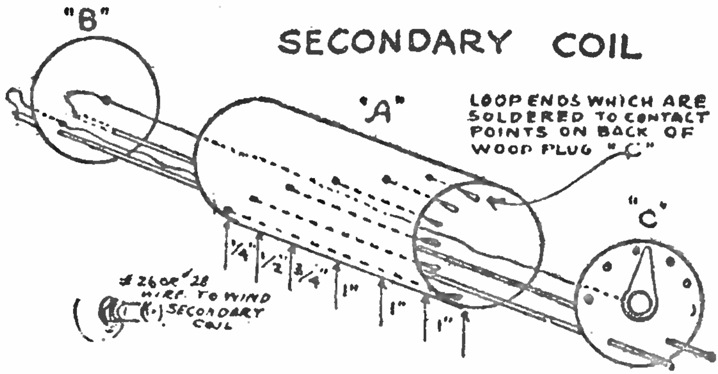
PRIMARY COIL

After winding fasten end of the wire with a small tack.



The Primary Coil is a paper tube 4x6 ins., mounted between blocks of wood and wound with one-half pound of No. 22 enameled copper wire, fastened as shown above. The block with circular hole to insert the secondary coil which slides back and forth on two 3-16 or ¼ in. round brass rods which are threaded on ends and mounted to allow free movement of secondary coil. After winding coil carefully remove protecting coat on wire ¼ in. wide at slider contact across coil.



A paper tube 3½x6 ins. wound with No. 26 or No. 28 cotton covered wire. To wind—start at left end of tube, make hole in tube, thread wire, leave end long enough to allow free movement of coil to extreme right. Now wind to the width of ¼ in. on surface. Make hole through tube, loop wire, push through hole and pull loop out a little beyond end of tube. Reach inside of tube and twist wire two or three times against inside wall, so that winding on surface will fit snugly. Proceed as before and wind space ½ in. wide and loop. Then ¾ in. Then finish winding with 1 in. spaces as shown in diagram above, fastening the end of wire with a small tack.

"B" circular wood plug with holes of proper size to allow round brass slider rods to pass through. "C" circular wood plug identical to "B" with contact points arranged as above and to which loop ends are soldered. Carry a wire from back of switch arm to end of brass slider rod, as shown in "B."

LOOSE COUPLERS

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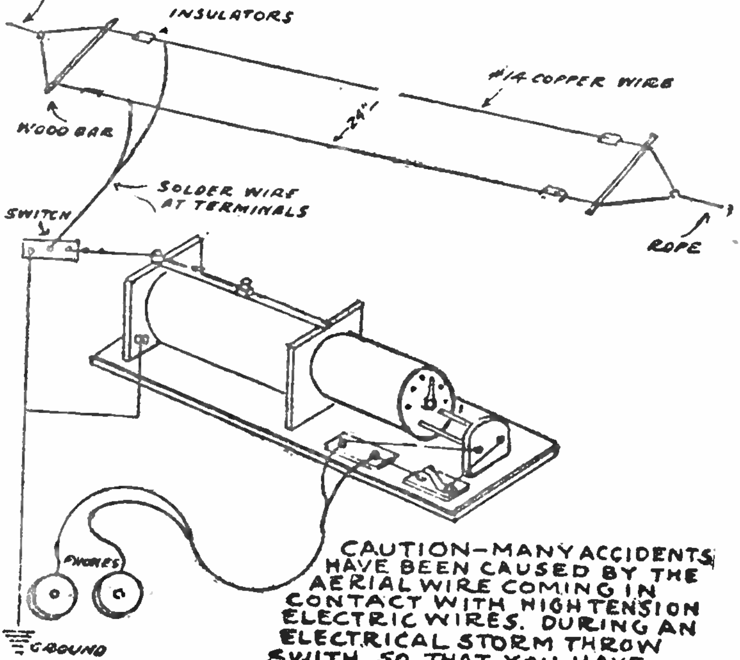
SET ASSEMBLED



CAUTION—MANY ACCIDENTS HAVE BEEN CAUSED BY THE AERIAL WIRE COMING IN CONTACT WITH HIGH TENSION ELECTRIC WIRES. DURING AN ELECTRICAL STORM THROW SWITH SO THAT YOU HAVE CIRCUIT TO GROUND.

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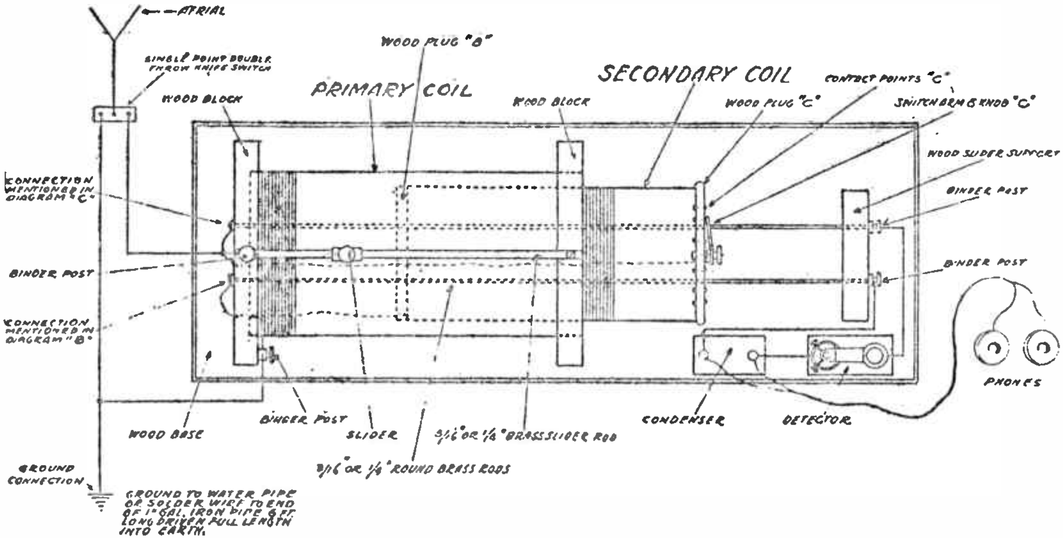

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In the receiving circuit just the cpposite conditions obtain. The transformer must have a large number of ampere turns to deal with the very weak currents with which to create a strong enough magnetic field necessary to make audible sounds in the telephone receivers.

A loose coupler consists of two windings, one sliding inside the other.

The outer one is called the primary, and the inner the secondary. The primary is connected to the aerial and ground; the secondary to the detector and phones of the receiving set.

All the wires leading from the primary to the aerial and ground make up the "primary circuit"; the wires connected to the secondary, the "secondary circuit."

The primary of the loose coupler in the accompanying diagrams, uses a slider for varying the inductance. However, some receiving transformers have a series of taps, or switch points, by which the tuning is done. The secondary is almost always tuned by means of these taps.

A loose coupler does not bring in signals any stronger than a tuning coil but reduces interference and enables much sharper tuning to be done.

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II

A Tuning Coil affords the simplest means of changing the wave length adjustment of a receiving set.

Some tuning coils have but one slider; others have three or four. One slider is sufficient for receiving signals, but in the reception of music sharper tuning is possible with two or more sliders. In making a tuning coil scrap the insulated wire so that a contact is possible with the slider.

Loose couplers and variometers are also known as tuning coils. The tuning coil shown here, while effective enough for amateur use, has long since been out of date in commercial stations.

The drawbacks to a tuning coil are that no variation of the mutual inductance of the two parts of the coil is possible, therefore making it inferior to the loose coupler or variometer as a sharp tuning device; also the contact in time loosens the winding causing short circuits and eventually wears through the wire. However, for amateur experimentation a loose coupler is well worth the time that may be spent in constructing one.

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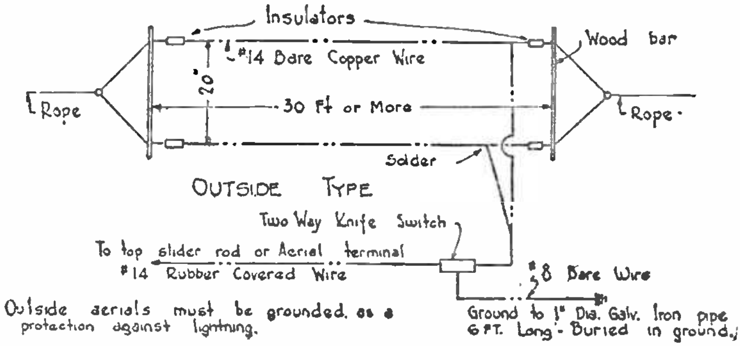
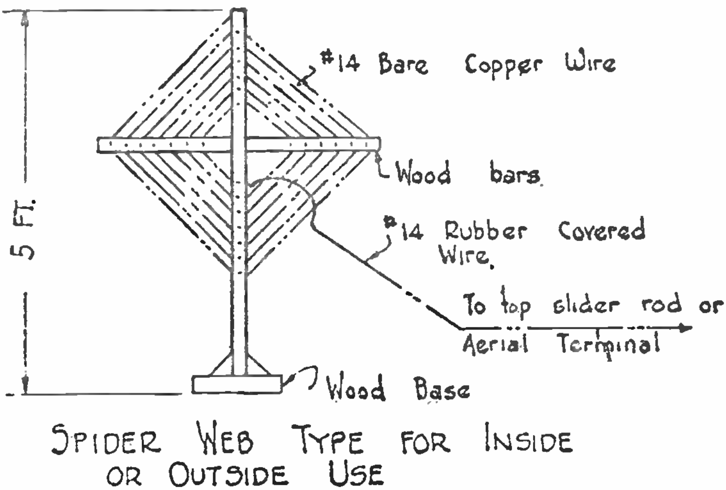
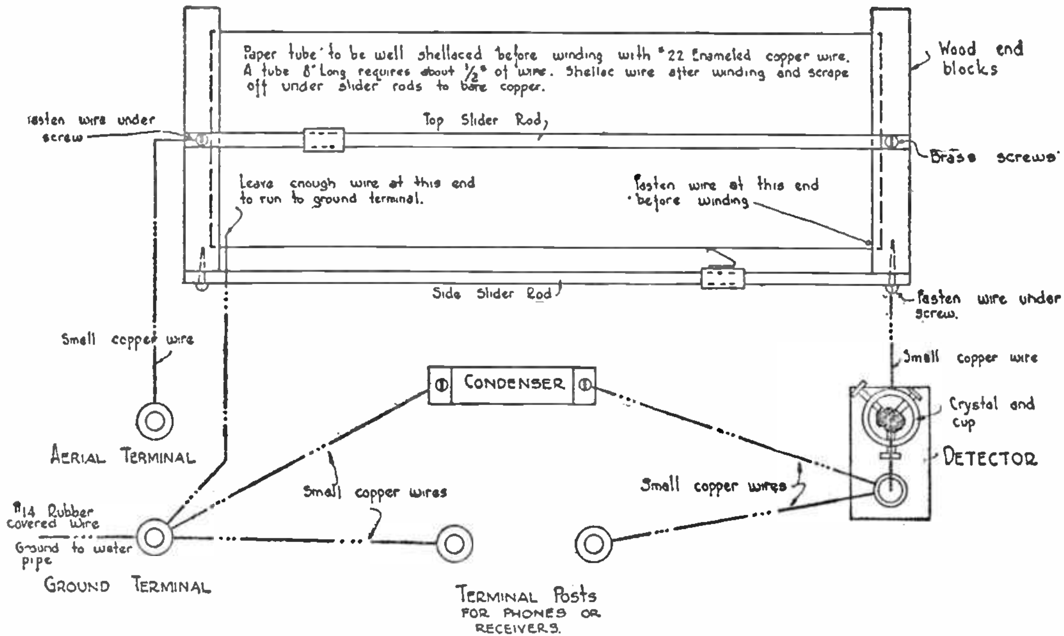




WIRING DIAGRAMS. TYPES OF AERIALS

World Radio History



WIRING DIAGRAM

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