No head-phones are necessary in order to hear signals with the 2-tu
A.C.–D.C. receiver.

FIRST RADIO BOOK FOR BOYS

BY

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Illustrated by the Author

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Preface

EVERY year thousands of boys build their first radio set. They glean their information from magazines, pamphlets, and the direction sheets supplied with kits of parts. This is not easy. It would seem that no one has much interest in the rank beginner.

But here is a book describing in detail the construction of several radio receivers which are as simple as it is possible to make them and get good results from their operation. All this apparatus for which plans and instructions are given has been built by twelve-year-old boys. If you can solder and are a careful workman you too can build it.

No attempt has been made to go into any great detail regarding the principles of radio. Principles have been explained only enough so that you will have some understanding of what you are doing.

If you wish to know more about the "why and wherefore" of radio and to have your questions about it answered, you should read the author's "Getting Acquainted with Radio," also published by D. Appleton-Century Company.

ALFRED MORGAN

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Photographs

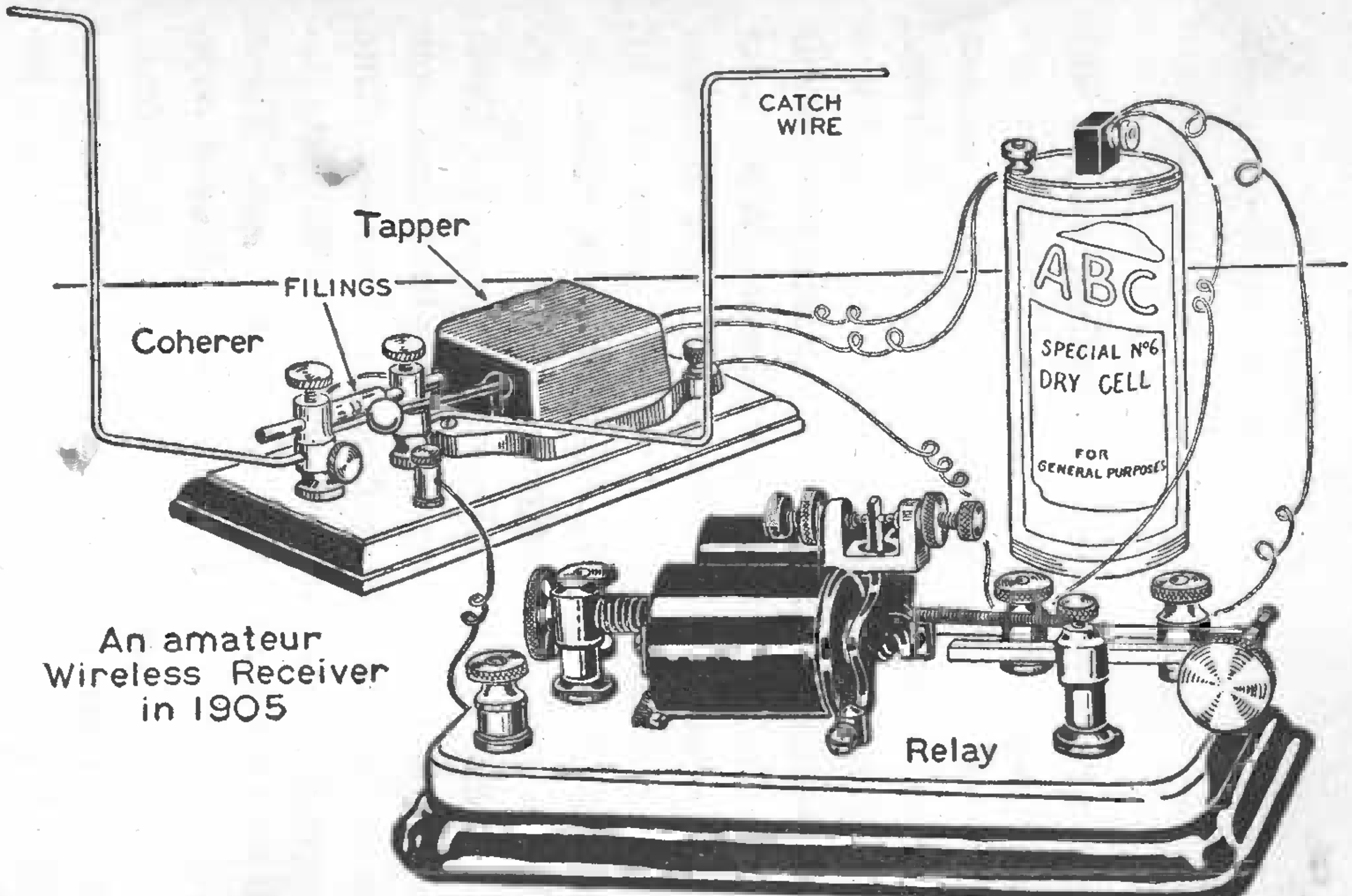
This book is made in full compliance with Government Directive L 120 limiting the bulk of paper.

FIRST RADIO BOOK FOR BOYS

Off the Record

More years ago than I care to remember, while I was still a boy in grammar-school, I became intensely interested in a new wonder, a scientific infant then known as wireless telegraphy. To be exact, it was in 1903. This was only two years after a young scientist named Guglielmo Marconi had astonished the world by sending telegraph signals across the Atlantic Ocean between Wales and Nova Scotia without any interconnecting wire or cable. My interest in the new art was awakened principally by reading articles about it in *The Scientific American.*

By reading and experimenting, I gleaned enough information to build my own wireless telegraph set. With two binding posts, two brass rods, a glass tube, and some filings from the edge of a dime, I made a "coherer." From an old electric door-bell I made a "tapper." An old telephone bell was changed into a sensitive "relay." These three instruments, properly connected and adjusted, composed the receiver. A telegraph key, a "jump-spark coil," and a spark gap made up the transmitter. The spark gap consisted of two pieces of brass rod with the ends separated about 1/32 of an inch. The "jump spark coil" was an old telephone induction coil which I fitted with an inter-



Just after the turn of the century when boys first began to tinker with "wireless" telegraphy, messages were received with a *coherer*. A coherer consisted of a few nickel and silver filings between two metal plugs enclosed in a glass tube. The rest of the apparatus comprised a *tapper* made from an old door-bell, a sensitive relay and a battery. The sketch shows the receiving equipment in a typical amateur wireless station in 1905.

rupter and a condenser. It produced a short, hot spark which jumped about $\frac{3}{32}$ of an inch, and was I proud of it! This may seem a collection of rough and crude apparatus, but it embodied the same principles utilized in some of the commercial equipment in use at that time.

The battery, too, was home-made. Four carbon rods and four zinc rods suspended in fruit jars containing a mixture of sulphuric acid, bichromate of potash and water, generated current for the coil. I had a great deal of trouble with my parents over this battery—wherever a drop of the terrific liquid contained in the jars fell on rug or clothing, it ate a hole. The coherer and spark coil were endured with suspicion, but the battery soon became a distinct social outcast.

However, my "wireless" was a success. It worked, and I was happy.

With it, I could send messages through space for 150 to 200 feet. Some people who saw this crude and mysterious apparatus in operation were intelligently interested. Others were amazed and skeptical. Some thought it a fake, and still others considered that I was quite "nutty" to fool with and believe in such a preposterous thing as telegraphing without wires.

You will find that there are still these four different kinds of people in the world.

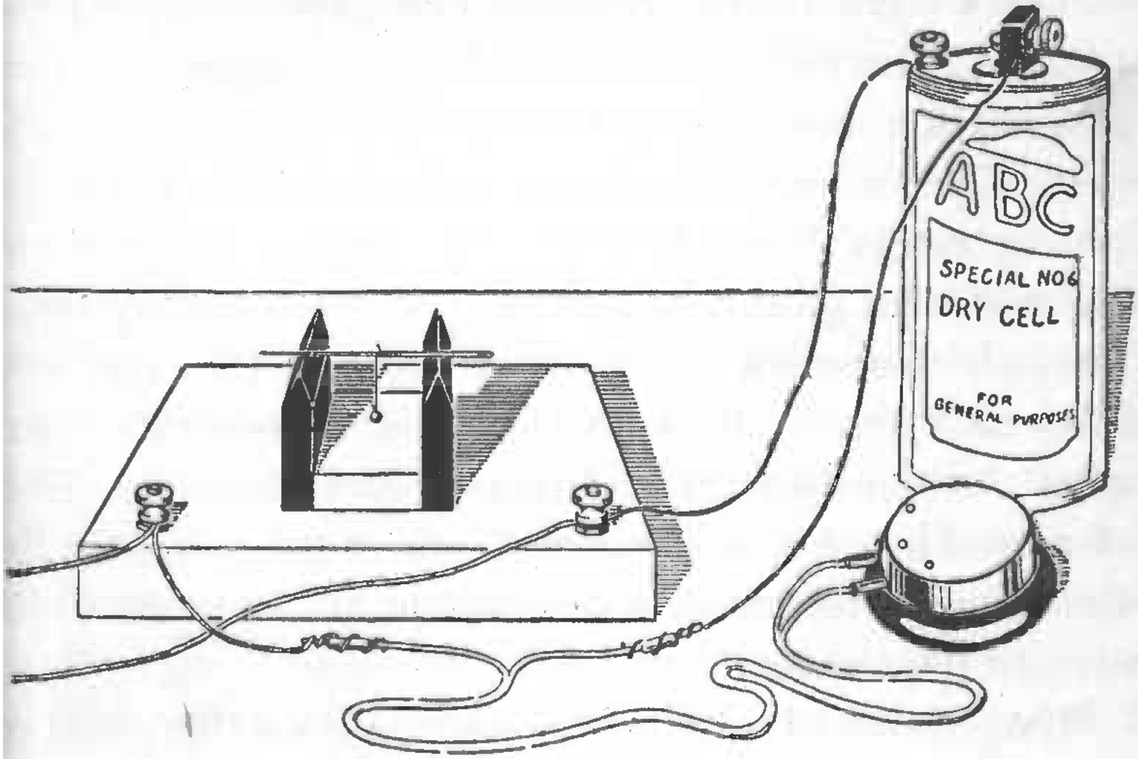
Wireless telegraphy was developing rapidly in those days. Coherers were soon replaced by microphonic "detectors" which employed a telephone receiver and were much more sensitive. So I built several kinds of microphonic detectors. I learned how to build an "electrolytic" detector during a visit to the wireless telegraph station, called PT, at the Brooklyn Navy Yard.

I hurried home from that visit and set to work. First, I rewound a telephone receiver with fine wire (No. 40 B.S.) to make it more sensitive, and built a "tuning coil" by winding some wire on a piece of wooden curtain pole. Then, with some nitric acid and Wollaston wire (silver-coated platinum wire .001 of an inch in diameter) purchased from Eimer and Amend, I built an electrolytic detector. This was accomplished by breaking a hole in an electric light bulb, poking out the filament and then partly filling the bulb with dilute nitric acid. A piece of Wollaston wire was attached to a fine screw and arranged so that the end dipped in the acid solution.

I was extremely happy when I found that I could receive signals from the Brooklyn Navy Yard at my home in Montclair, New Jersey, with this new equipment.

At that time boys actively interested in wireless telegraphy probably numbered less than a baker's dozen. They were scattered about the country but were destined to grow into that intrepid band called "hams" and "amateurs"—now nearly 100,000 strong.

I visited the Children's Museum in Brooklyn, where an unusual young woman, Miss Mary Day Lee, a member of the Museum staff, not only encouraged boys to experiment with electricity and wireless telegraphy but actually was able to aid and assist them. My hat is still



THE FIRST DETECTORS

The coherer of the early days of wireless telegraphy was soon superseded by various microphonic detectors. One form of microphonic detector once used by many amateurs consisted of a steel needle resting on the sharpened edges of two carbon blocks. This was connected in series with a battery and a telephone receiver. Observe the old-fashioned dry cell illustrated in the sketch above. Notice the carbon in the center of the cell is a flat plate and not the round rod used in the dry cells of to-day.

off to the young woman who could discuss with you the fine points of winding a spark coil. There at the Museum I also met Austen M. Curtiss and Lloyd Espenschied, boys of my own age and two of Brooklyn's four known "wireless amateurs" at that time.

Wireless telegraphy was growing and changing rapidly in those days. More and more ships were being equipped with apparatus and more land stations built.

There was a United Wireless Telegraph Company station at 42 Broadway in New York City, a Marconi station at Sea Gate, near Coney Island, N. Y. Crystal detectors using Carborundum or silicon replaced other less sensitive detectors. Variable condensers for tuning came into use and with all this, a new crop of amateurs, equipped not only to receive but to crash and splutter every evening with transmitters consisting of home-made spark coils and transformers that no one could tune out. Each one tried to see who could make the most noise. By this time there were many thousands of amateurs scattered about this country.

The growth of wireless telegraphy from this point on is a story too long to recite here. So we will skip to that time just before the World War when that marvelous device called the three-element vacuum tube was coming into wide use. Wireless had grown up. It had become radio.

But so had the amateurs grown up. Since the earliest days of wireless there had existed this earnest band of experimenters of varying capabilities. Some were amateurs in the sense that wireless to them was only a hobby. They were attracted by the novelty and interest of signaling to each other and cared little about scientific inestigation. On the other hand, there were many who ad a standard of knowledge equal to that of professional adio men.

During the war, the activities of the amateurs neces-arily ceased. Many of them lent their knowledge and kill to their country. Some of the most able and proficient ıstructors and operators in the Army and Navy were x-amateurs.

After the war, amateurs using very small power, by in-enuity, resource and perseverance, developed short-vave radio transmission and reception to such a degree hat it proved to be a far more dependable method of ong-distance communication than the long waves used y commercial companies. For many years, the profes-ional radio engineer neglected short waves only to have shown to him that there was an unknown set of phe-omena of extreme usefulness at his very door and that had been first found and developed by "amateurs."

All these years, while radio was growing up, so was I became a manufacturer of radio apparatus. I manu-actured both amateur and commercial equipment, and pparatus for the United States Army and Navy. I pio-eered in broadcasting. But all this time I still remained n amateur at heart, a "kid" with a spark coil and a rystal detector.

I have never lost a sense of awe for radio science or a ellow-feeling with the lad who likes to putter with antennae and oscillators. There are many scientific and engineering books about radio. There are many books for young men who want to "get on the air" with a modern transmitter and communications receiver. But the lad who is a rank beginner, who wishes to build a crystal receiver and a one- or two-tube set has been neglected. It is for him that I have written this book.

CHAPTER I

An Explanation of Radio

If we choose among the marvels of electricity and pick the five which have brought the greatest benefits or changed our way of living most, we will have to name:

The Telegraph
The Telephone
The Electric Light
The X-Ray
The Radio.

Until the telegraph and telephone were invented, a galloping horseman or men wigwagging and signaling from hill to hill were the fastest means of sending a message from one place to another.

Before the first electric light was made, the only source of illumination in the world after sundown was some sort of fuel-consuming flame.

The X-ray brought a window through which a physician can see fractured bones, foreign bodies, and a host of human ills which had previously been hidden from his eyes unless he performed a surgical operation.

Radio was born less than fifty years ago. At first, its greatest feat was to splutter dot and dash telegraph messages to ships at sea where the wires and cables of the telephone and the land telegraph could not reach. It could hear the far-off cry of a vessel in distress and send assistance.

Then through the magic of a small lamp which can perform miracles almost as amazing as those ascribed to Aladdin's wondrous teapot-like affair, radio still further magnified our senses—gave them powers beyond all biological possibility. Radio's Aladdin lamp, the vacuum tube, gave us the radiophone, television, and the amplifier. Our eyes began to see what is happening beyond the horizon. We could hear voices and music in a faraway country. Tiny sounds, heretofore too feeble for human ears, could be amplified and heard.

There is no hobby so fascinating as radio and the tricks of the vacuum tube for those who like science and handicraft.

As a name for the science and art which embraces the many uses of the vacuum tube, the word *electronics* has been coined.

Radio and electronics are the highest branch of electrical engineering and include a great deal of the science of physics. A radio engineer's textbook, and, in fact, many volumes written for amateurs, are about as plain to the beginner as a book written in Sanskrit would be.

Learning something about radio is like learning to swim. Keep out of deep water at first. It is not necessary to plunge into radio over your head and try to understand highly technical language and complicated apparatus. You can assemble a simple radio receiver merely by following a good plan and set of instructions.

This volume is intended for the lad who knows little or nothing about radio. Its purpose is to instruct him in venturing into the amazing field of electronics by building and operating some simple radio receivers and associated apparatus. It is purely a beginner's book. It is not for the licensed amateur.

From this point, if you wish, you can skip the rest of the chapter. You can also skip Chapters II and III, turn to page 65, and start building a radio receiver.

But there are certain things which ought to be explained, some questions to be answered. So here, before any instructions for building and operating apparatus are given, you will find a simple exposition of the manner in which radio messages are sent and received. It may answer some of your questions.

HOW RADIO CONQUERS SPACE

How is it that a radio message sent from New York, Chicago, London, in fact sent from any place, often can be heard over a great part of the earth? The land telegraph and the telephone use wires. No connecting wires or cables are used in radio. How does a radio message reach an airplane, a ship at sea? Seemingly a radio message can be plucked out of the air anywhere.

Radio messages are carried through *space* by invisible waves. The waves are man-made. They are produced when very rapidly *alternating* currents flow through a coil or wire. Strong, rapidly alternating currents can produce powerful waves which will carry messages around the world.

A sensitive device called a *detector* makes the message audible and, in some cases, visible.

Put "in a nutshell," sending and receiving radio messages consists of creating invisible waves and of detecting the waves.

The apparatus used for this purpose, if low-powered, may be small and simple enough to hold in the palm of your hand. Its energy may come from a flash-light battery. Or, if powerful and sensitive, it may fill a large room and require the energy of a 50-kilowatt generator.

RAPIDLY ALTERNATING CURRENTS

The rapidly alternating currents used to generate radio waves are called oscillatory, high-frequency, and radio-frequency currents.

The current from batteries, the current called *direct* current, flows in one direction. It moves like a stream of water through a hose.

Alternating currents do not flow steadily through a wire, always moving forward like a stream of water. They move first in one direction and then in the opposite direction. They swing back and forth like the pendulum on a clock. The alternating current used for house-lighting makes sixty complete swings every second. Radio-frequency currents swing back and forth thousands of times per second.

Radio-frequency currents will do many of the things which direct currents will do. But they have also some special tricks of their own. One of them is to create radio waves.

WAVES IN SPACE

Radio waves have two other names. They are called electromagnetic waves and occasionally Hertzian waves after Heinrich Hertz. Hertz was the man who discovered how to create them. Sometimes radio waves are wrongly called "air waves." That is newspaper slang. It is a misleading name. Radio waves have nothing to do with the air and air has nothing to do with them. We can be thankful they are not "air waves." If they were, a strong wind would blow them away.

No, radio waves travel by some medium which is not air. It is, in fact, a mystery. They travel through space, the space in which we, our earth, the sun and moon and stars exist. The same medium that carries radio waves carries our light. The light falling on this page, coming from a lamp on a near-by table, or coming from the sun, 90,000,000 miles away, is borne by the same medium that bears the radio waves. Whatever it is, this medium can not be weighed or measured.

Radio waves and light waves are similar. They differ only in their length and in the number of times per second they occur. Radio waves are longer than light waves and they do not occur as many times per second. In the language of the engineer, radio waves are of lower *frequency* than light waves.

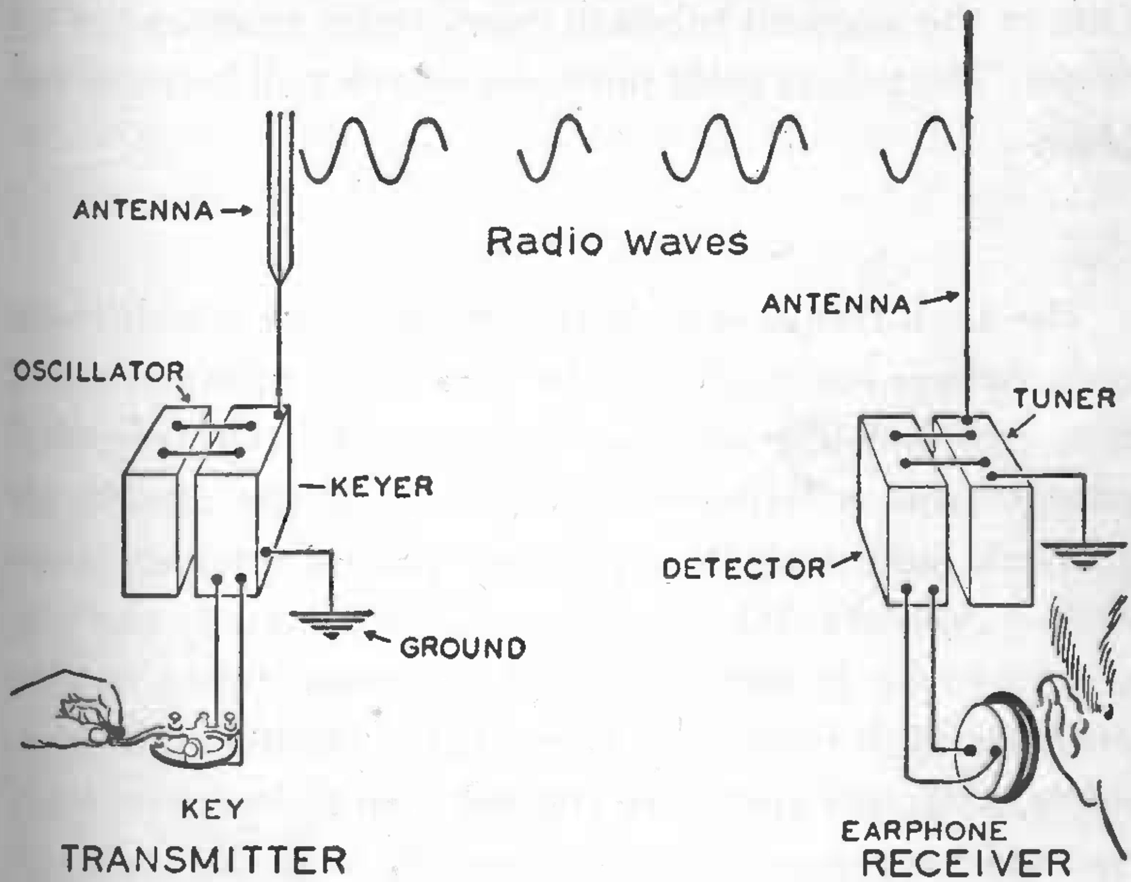
Many of electricity's tricks will work backward. Electricity may be changed into heat; heat into electricity. Electricity will make magnetism; magnetism will make electricity.

Electricity will produce radio waves; radio waves will produce electricity. There in one sentence is the fundamental principle of radio. High-frequency currents, surging back and forth in a wire or coil, create radio waves.

Radio waves, spreading out like the ripples on the surface of a pond when struck by a stone, go traveling through space. Their speed is terrific, approximately 186,000 miles per second. Light travels at the same speed.

When radio waves strike a wire or a coil of wire, they *create* radio-frequency currents in that wire or coil. These currents are like those which originally created the waves

RADIOTELEGRAPH



A radiotelegraph transmitter consists of an oscillator for generating high-frequency currents which produce radio waves when they flow into the antenna system. The waves are broken up into groups corresponding to dots and dashes by a device called a *keyer.* The keyer is a form of modulator for giving the message to the radio waves and is controlled by a telegraph key. The waves are intercepted by the receiving antenna, and the high-frequency currents generated therein pass through a tuner and a detector. The tuner blocks out unwanted messages. The detector and telephone receiver change the high-frequency currents into sound and make the message audible.

except that they are weaker. They have only an infinitesimal part of the energy of the original wave-producing current.

To discover and disclose these tiny currents created by radio waves which reach the receiving station, a *detector* is used. To-day, the detector is usually a vacuum tube. One of the vacuum tubes in every radio receiver is a detector. The others fulfil purposes which will be explained later.

TRANSMITTER TUBES

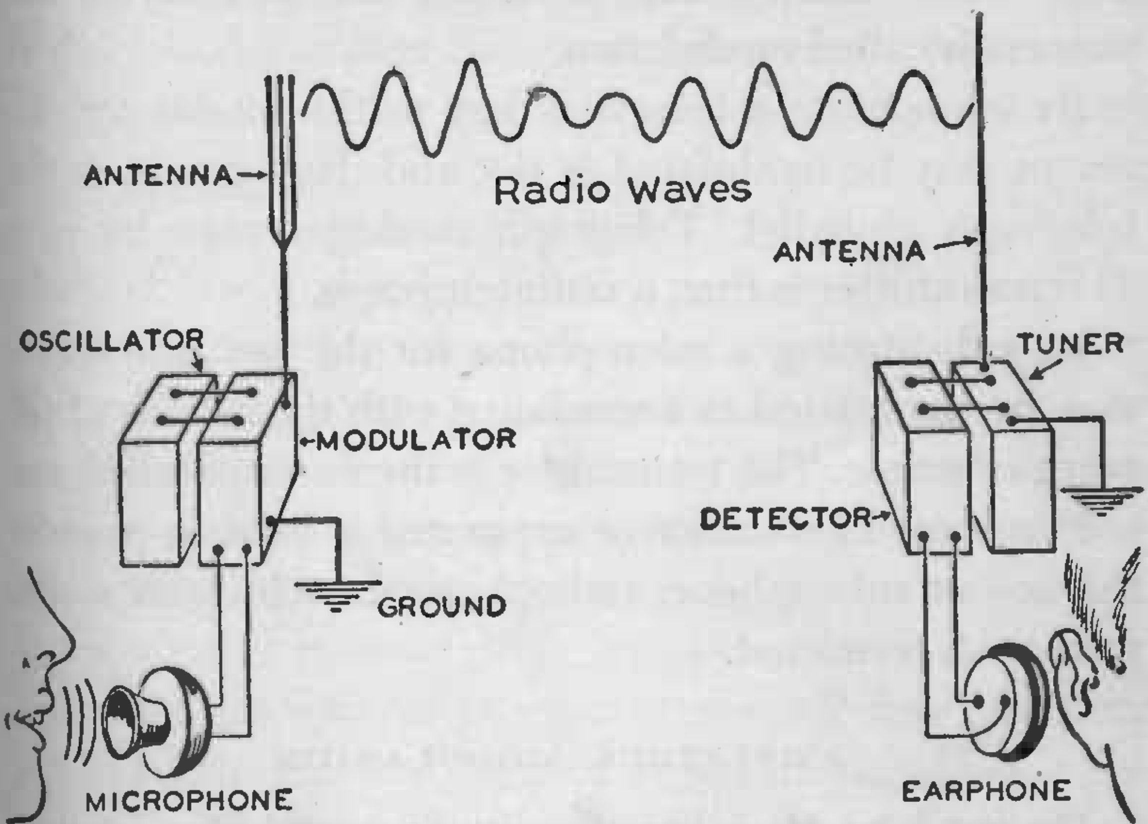
The high-frequency alternating currents which create radio waves are produced by a vacuum tube connected to a coil and a condenser and supplied with electrical energy from a battery or generator. If the circuits are properly adjusted, they produce radio-frequency alternating currents. When engaged in this activity the tube is said to be in *oscillation*. The vacuum tubes used to generate high-frequency currents for sending radio messages are larger and more rugged than the vacuum tubes in a radio receiver. They are specially made for their purpose and are called transmitter tubes.

THE MODULATOR

Do not gain an idea from this explanation of the basic principles that a radio transmitter consists only of a tube, a coil, and a condenser or that a receiver comprises only a detector tube. There is more to it all than that. At this time we are talking about the fundamental things of radio and trying not to "get in over our heads."

Some sort of apparatus is necessary at the transmitter for giving the message to the radio waves. The message

RADIOTELEPHONE



A radiotelephone transmitter consists of an oscillator for generating high-frequency currents which produce radio waves when they flow into the antenna system. The waves are given their message by a device called a *modulator* connected to a microphone into which music or speech is directed. The waves are intercepted by the receiving antenna and the high-frequency currents generated therein pass through a tuner and a detector. The tuner blocks out unwanted messages and interference. The detector and telephone receiver change the high-frequency currents into sound and make the message audible. The apparatus used to receive radiotelephone messages is similar to that used to receive radiotelegraph signals. The difference between a radiotelephone transmitter and a radiotelegraph transmitter is that the radiotelephone employs a microphone in place of the telegraph key used in a radiotelegraph.

may be a picture, spoken words, music, or the dots and dashes of the telegraph code. It may be a sports event or some other scene being televised. Whatever it is that is to be flung out into space, the apparatus for giving the message to the radio waves is called the *modulator*. The process is called *modulation*.

By connecting a telegraph key to the modulator, the waves may be modulated in dot and dash groups of the telegraph alphabet. Telegraph messages may be sent. The transmitter is then a radiotelegraph.

By substituting a microphone for the key, the waves may be modulated in accordance with the sounds of the voice or music. The transmitter is then a radiotelephone.

If special light-sensitive apparatus is used in place of the key or microphone, radiophotos or television scenes may be transmitted.

AMPLITUDE MODULATION

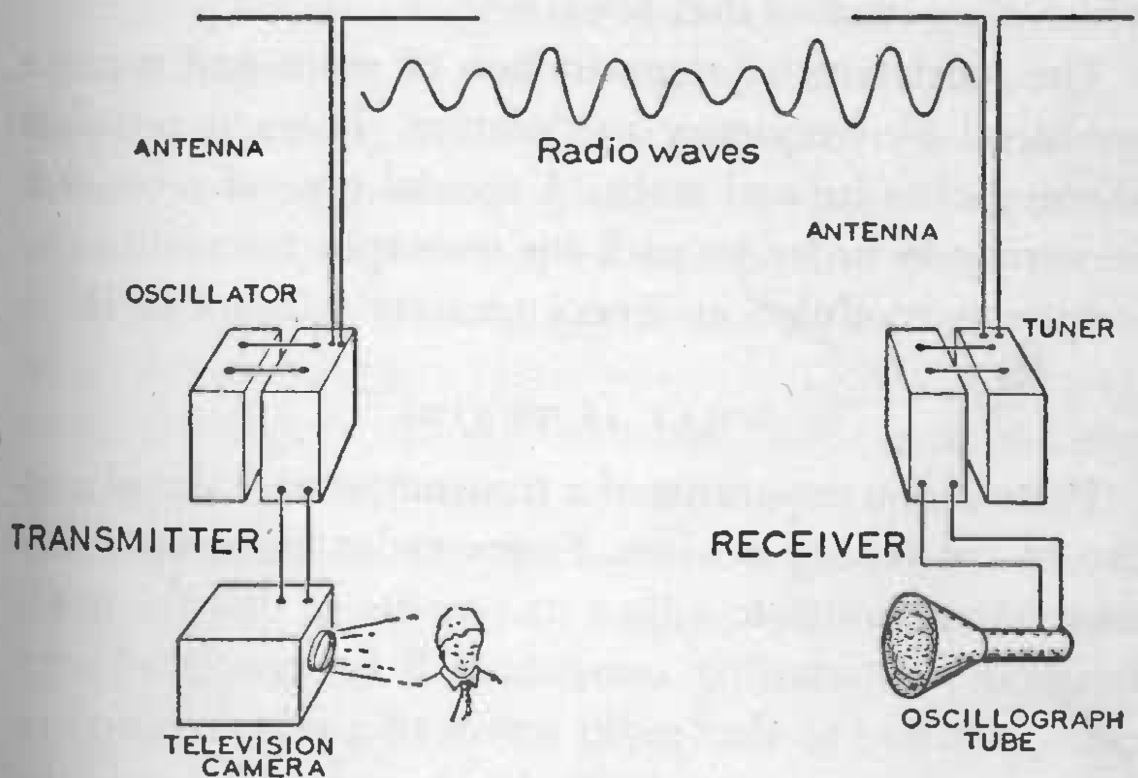
Do not let a term like *amplitude modulation* frighten you. It is simple when explained.

There are two basic methods of giving radio waves their message to carry. The older method and the one in almost universal use at the time this book is written changes or modulates the *strength* of the waves and is called *amplitude* modulation.

WHAT IS FREQUENCY MODULATION?

The newer method, perfected by Professor E. H. Armstrong and undoubtedly destined to come into wide use, is called *frequency* modulation. In this system, when the

TELEVISION



Radio television is similar to radio telegraphy and radio telephony in so far as it consists of sending and receiving electric waves.

Radio television employs an oscillator as part of its transmitter. The oscillator generates high-frequency currents which produce radio waves when they flow into the antenna system. The waves are given their picture message by a modulating device connected to a television camera. A moving beam of light scans, that is examines, the scene to be sent and varies the outgoing waves according to the light reflected from the different portions.

The waves are intercepted by the receiving antenna and the high-frequency currents therein pass through a tuner, detector and amplifier, quite similar to an ordinary radio receiver. The picture message can not be made visible by telephone receivers or loud speakers and so a device called an oscillograph tube is used. In this a moving beam of electrons controlled by the incoming radio waves paints a fluorescent picture on a sensitive chemical screen at the end of the tube.

radio waves are given a message to carry, it is not the strength but the *frequency* of the waves—or the rate at which they occur—that is varied.

The most faithful reproduction of voice and music is produced by frequency modulation. There is complete absence of noise and static. A special type of receiver is necessary in order to pick up messages transmitted by frequency modulation. Every receiver will not do it.

WHAT IS TUNING?

Parts of the apparatus of a transmitter and also of a receiver are *tuning* devices. Every radio transmitter uses its tuning devices to adjust its circuits so that the radio-frequency alternating currents will be generated most efficiently and so that radio waves of a certain length or frequency are emitted. Radio *transmitters* must be licensed, and here in the United States the Federal Radio Commission assigns a certain frequency to each station. The station is permitted to operate only on the frequency or frequencies specified in its license.

Tuning devices in the receiver are necessary in order to put the receiving equipment in proper adjustment with the waves radiated by that transmitter whose message is to be received. Tuning not only strengthens and brings in the desired message but it blocks or bars those from other stations which are undesired at the time.

ANTENNAE

Every radio transmitter and every radio receiver must employ some form of wire or coil called an antenna. In the case of a transmitter, the antenna may vary from a short metal rod to a network of wires suspended from a high tower. The type of antenna used at the transmitter is determined by the power of the station and the frequency of its waves.

Receiving antennae may be a small coil or a single wire varying from a few inches to many feet in length. The type and length of antenna used by a receiver is usually determined by the frequency of the waves which are to be received, the location of the receiver, and the facilities available for supporting the antenna wire.

CHAPTER II

Things You Should Know about Antennae, Ground Connections, Radio Symbols, and Soldering

THE PURPOSE OF AN ANTENNA

EVERY radio transmitter and every radio receiver employ some form of wire or coil called the *antenna.* The purpose of the antenna connected to a transmitter is to radiate the waves. When connected to a receiver, it is the antenna which picks up or intercepts the waves.

To receive radio messages, it is necessary only to connect a tuning device, a pair of head-phones, a detector, and a condenser to an antenna and to the ground.

The tuning device may be a simple coil of wire with a sliding contact arranged so that the amount of coil included in the circuit can be varied. Adjusting the tuning coil puts the receiving circuit "in tune" with the waves radiated by the transmitter. Then it will respond efficiently only to those waves and block out any unwanted messages.

When the high-frequency alternating currents created in the antenna by the incoming waves pass through the detector on their way to the ground, the detector changes them into *direct* currents.

The purpose of the head-phones or speaker is to change the direct currents produced by the detector into sounds and thus render audible the message carried by the waves.

THE PURPOSE OF THE DETECTOR

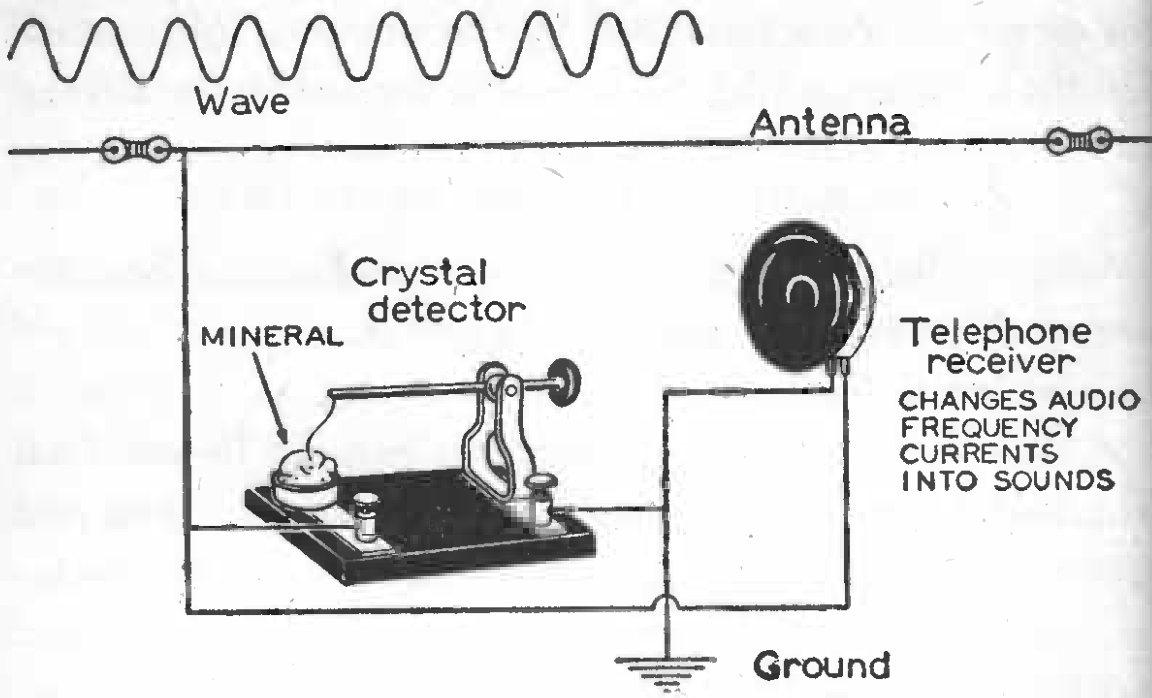
Why could the head-phones or speaker not be connected directly to the aërial and ground?

Why is a detector used?

A detector is necessary. Messages can not be received by connecting the head-phones directly to the aërial and ground. The currents generated in the antenna by the incoming waves are high-frequency currents and will not produce any sound if sent directly into the head-phones. There are several good reasons why this is so.

One of them is that the small electromagnets or coils in phones or speakers choke back radio-frequency currents and do not allow them to pass. Phones or speakers will respond to direct currents or to low-frequency alternating currents.

Another reason is that it is not possible to make a telephone receiver or speaker diaphragm which will vibrate rapidly enough to respond to high-frequency currents. If such a diaphragm could be made, the sounds produced by a diaphragm vibrating so rapidly could not be heard. The average human ear will not respond to vibrations much over 10,000 per second. The high-frequency currents produced by a radio wave are much more rapid than that.



THE ESSENTIALS OF A RADIO RECEIVER

An antenna, a detector, and a telephone receiver are the essentials of a simple, untuned radio receiver. The incoming radio waves, bearing a message which may be the *dits* and *dahs* of the telegraph code or voices and music, strike the antenna. The waves create high-frequency currents in the antenna which pass through the detector. The detector changes the high-frequency currents into direct currents which produce sounds in the telephone receiver.

A simple, untuned radio receiver is considerably improved by the addition of *tuning* devices to adjust the antenna and other circuits. If a radio vacuum-tube detector is substituted for the mineral detector, the receiver becomes more sensitive; it will receive messages from greater distances. Such changes also necessitate certain auxiliary apparatus such as resistors, condensers, etc. Although a receiver such as that shown above will actually pick up radio messages, it would not be practical in these days. It would receive several messages at the same time and they would be jumbled.

ANTENNAE

There are many different forms of antennae, varying from a single wire to the complicated "arrays" and "signal squirters" used for sending and receiving very short radio waves. Amateur radio operators roll "Marconis," "Hertz," "Zepps," "end-feed," "doublets," "flat-top beam," and so on, off their tongues when talking about antennae and seem to enjoy the taste of the words. They are the names of different types of antennae. But the novice, the beginner who is building his first radio receivers, should concern himself only with the simplest form of antenna, a horizontal wire having a "lead-in" attached to one end. The lead-in is simply a wire which is connected to one end of the antenna and leads from there to the receiver.

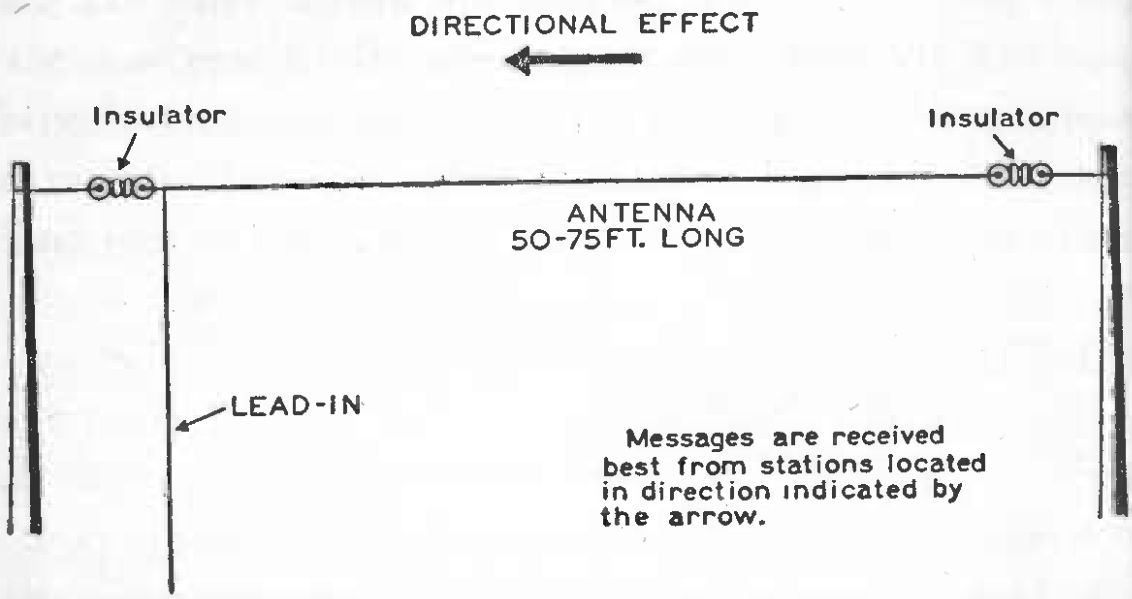
YOUR FIRST ANTENNA

A horizontal wire, fifty to seventy-five feet long, properly insulated, and as high and clear of surrounding objects as possible is the "best all around" antenna for the novice. It is connected to the receiver by a lead-in. The receiver is also connected to the ground. The arrangement is called a *Marconi* antenna.

A height of at least thirty to fifty feet above ground is desirable. An ideal location is not always available, but so far as may be possible, keep the antenna away from chimneys, tin roofs, gutters, drain pipes, walls, telephone wires, power wires, tree branches, and other antennae.

Whenever possible, an antenna and lead-in should be one continuous piece of wire. If it is made of more than one piece, all splices should be carefully soldered. No. 14 B. S. gauge hard-drawn copper wire may be used, but stranded copper antenna wire, obtainable at any radio store, is preferable.

The insulation of the antenna is of prime importance.



A SIMPLE RECEIVING ANTENNA

The best "all around" antenna for a receiver is that illustrated above. It consists of a single, horizontal wire (No. 14 B. S. hard-drawn copper) insulated from its supports at both ends. A height of 30–50 feet is desirable. Use at least one 3-inch glass antenna insulator at each end. When trees are used as supports, remember to let the antenna hang slack so that the tree can sway in the wind without straining the antenna.

Put at least one three-inch glass insulator at each end. The lead-in should not approach the side of a building closer than six inches except at the point where it enters. The best method of bringing a lead-in into a building is to pass it through a glass or porcelain tube set in the wall or window frame. An antenna lead-in strip may be used: this is a strip of copper covered with insulation and is thin enough so that it may be laid on the window-sill and the sash will close down on it.

All antennae, except a single perpendicular wire, receive signals better in one direction than in others. In the case of a horizontal wire, messages will be received best which come from a direction opposite to that toward which the free end points. The free end of the antenna is the end opposite that to which the lead-in is attached.

AN ANTENNA DOES NOT ATTRACT LIGHTNING

The ordinary antenna does not attract lightning and does not increase the chances that your home will be struck.

When lightning strikes in the immediate neighborhood, an antenna frequently picks up an induced charge. In order to lead this charge harmlessly into the ground, a lightning arrestor should be provided. A lightning arrestor is an inexpensive device consisting of a small spark-gap sealed in a vacuum so that the gap can be jumped by a charge of comparatively low voltage. The lightning arrestor should be placed outside the building at the point where the lead-in enters. One terminal is connected to the lead-in, the other connected to the ground. Connection is made to the ground by means of a wire attached to a ground rod. A ground rod may consist of a piece of ¾″ galvanized iron pipe or one of the copper-plated steel rods obtainable at a radio shop. A ground clamp should be used for connecting wires to pipes or rods.

THE GROUND CONNECTION

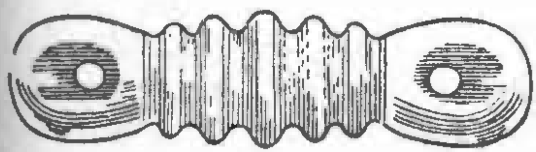
A radio receiver connected to a Marconi type of antenna must be grounded. A good ground connection is important. It increases both the transmitting and the receiving range of a station.

A ground connection suitable for a receiver can usually be secured by running a wire to the nearest water pipe. The pipe should be scraped bright and clean with a file at the point of connection, and the wire attached by means of a ground clamp. It is important to make a good electrical connection.

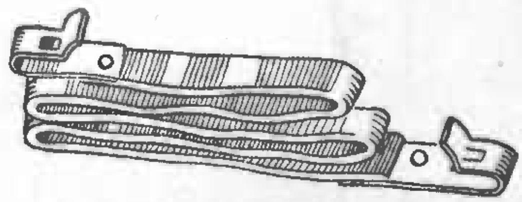
When there is no water pipe available within forty or fifty feet of the receiver, a ground can be established by connecting it to a number of copper wires (No. 14 B. S. gauge or larger) buried just below the surface of the earth and extending outward from a common point like the spokes of a wheel from their hub. Or a sheet of copper may be buried in the ground in place of the wires and connection made to it.

An arrangement called a counterpoise makes a good substitute for a ground. This consists of a number of wires spread out fanwise just above the surface of the ground. The wires are mounted on insulators attached to low posts or stakes driven into the earth.

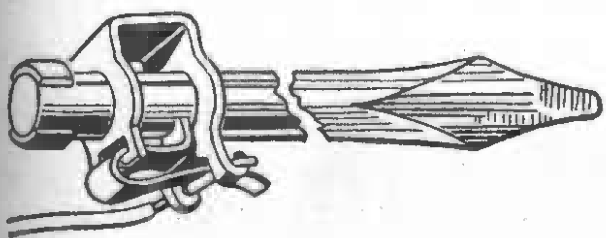
ANTENNA ACCESSORIES



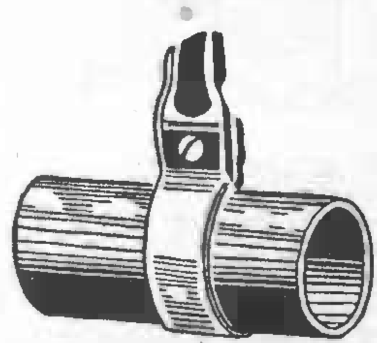
Glass Antenna Insulator



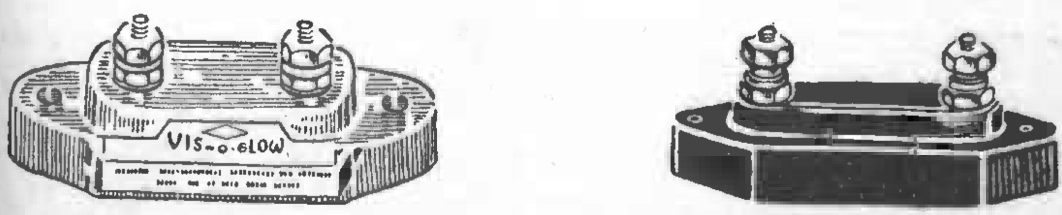
Lead-in Window Strip



Ground Rod



Pipe Clamp



Lightning Arresters

These inexpensive devices will improve the efficiency of your radio receiver. Of course lightning arrestors do not play any part in the actual operation of the apparatus, but they are an essential protection.

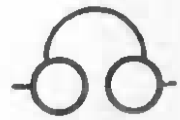
RADIO CIRCUIT SYMBOLS

The same radio circuit can be illustrated by two different types of diagram. One is called a pictorial diagram

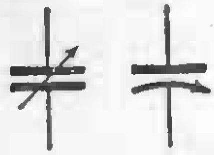
SYMBOLS USED IN CIRCUIT DIAGRAMS

ANTENNA

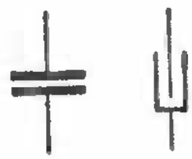
GROUND



TELEPHONES

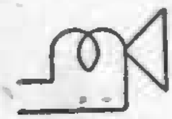


VARIABLE CONDENSER

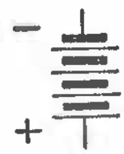


FIXED CONDENSER

CRYSTAL DETECTOR

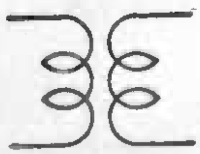


SPEAKER

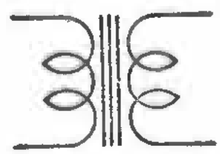


BATTERY

SINGLE CELL

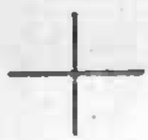


AIR-CORE TRANSFORMER

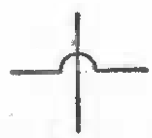


IRON-CORE TRANSFORMER

VARIABLE OR TAPPED RESISTANCE

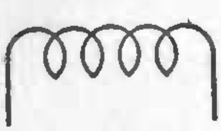


WIRES CONNECTED

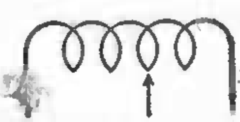


WIRES CROSSING NOT CONNECTED

RESISTANCE GRID LEAK



INDUCTANCE OR RADIO-FREQUENCY CHOKE

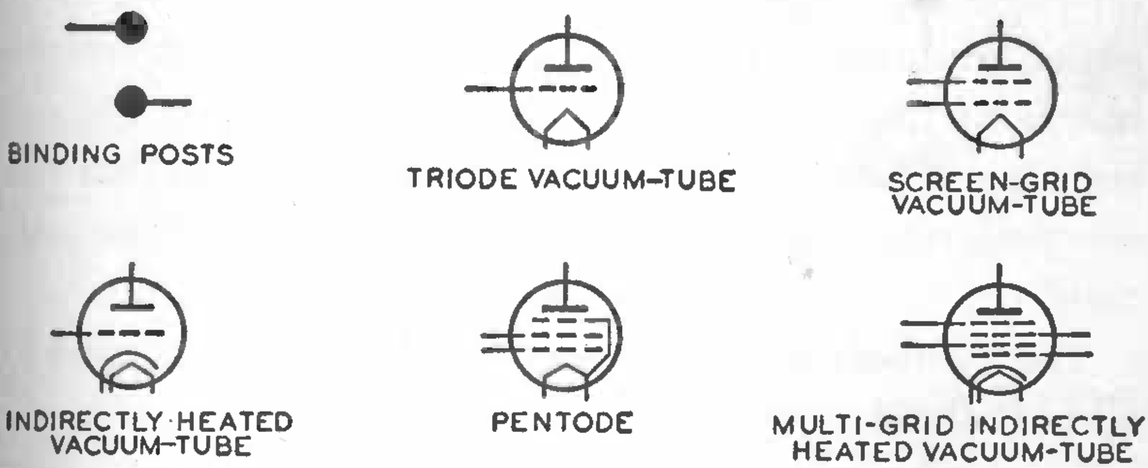


VARIABLE OR TAPPED INDUCTANCE

KEY

SWITCH

SYMBOLS USED IN CIRCUIT DIAGRAMS
CONTINUED



These symbols are a sort of radio shorthand used to make *schematic* circuit diagrams. Since this is a book for beginners, pictorial as well as schematic circuit diagrams are used. When you become acquainted with these symbols —and they are the same ones used in all radio books and magazines—you will find that they show a radio circuit more clearly than the pictorial method. The pictorial diagrams will be more easily understood in the beginning.

and the other a schematic diagram. You will find a pictorial circuit diagram of a simple receiver on page 34, and below it a schematic diagram of the same circuit.

The pictorial diagram is most easily understood by the beginner. But a pictorial diagram of an elaborate receiver would be difficult to draw and many of the connections would be obscure.

The radio engineer and the experienced radio amateur prefer the schematic diagram. In this, symbols are used to indicate the various condensers, tubes, resistors and other parts which compose the circuit.

As soon as you understand the meaning of these symbols, radio circuit diagrams will no longer be a mystery to you. The various symbols used in this book are shown on page 30. Copy a few radio diagrams on a sheet of paper, and, using the chart as a guide, write down the names of the different devices which appear in the circuit. It will help you to memorize the symbols so that you can understand schematic diagrams and even draw your own.

The symbols shown are the standard symbols used in all radio books.

SOLDERING

Soldering plays an important part in the successful building of radio apparatus. The wires used to connect the various parts must be soldered to the terminals.

Soldering is not difficult, and you should master the art if you wish to build your own radio apparatus.

Practice soldering by following the instructions, and if your efforts do not result in neat, firm joints ask some one who has had more experience to aid you and show you the trick.

Use "push-back" wire in making connections. This is copper coated with tin, and solder will adhere to it easily. It is not necessary to cut and scrape off the insulation. It may be pushed back out of the way.

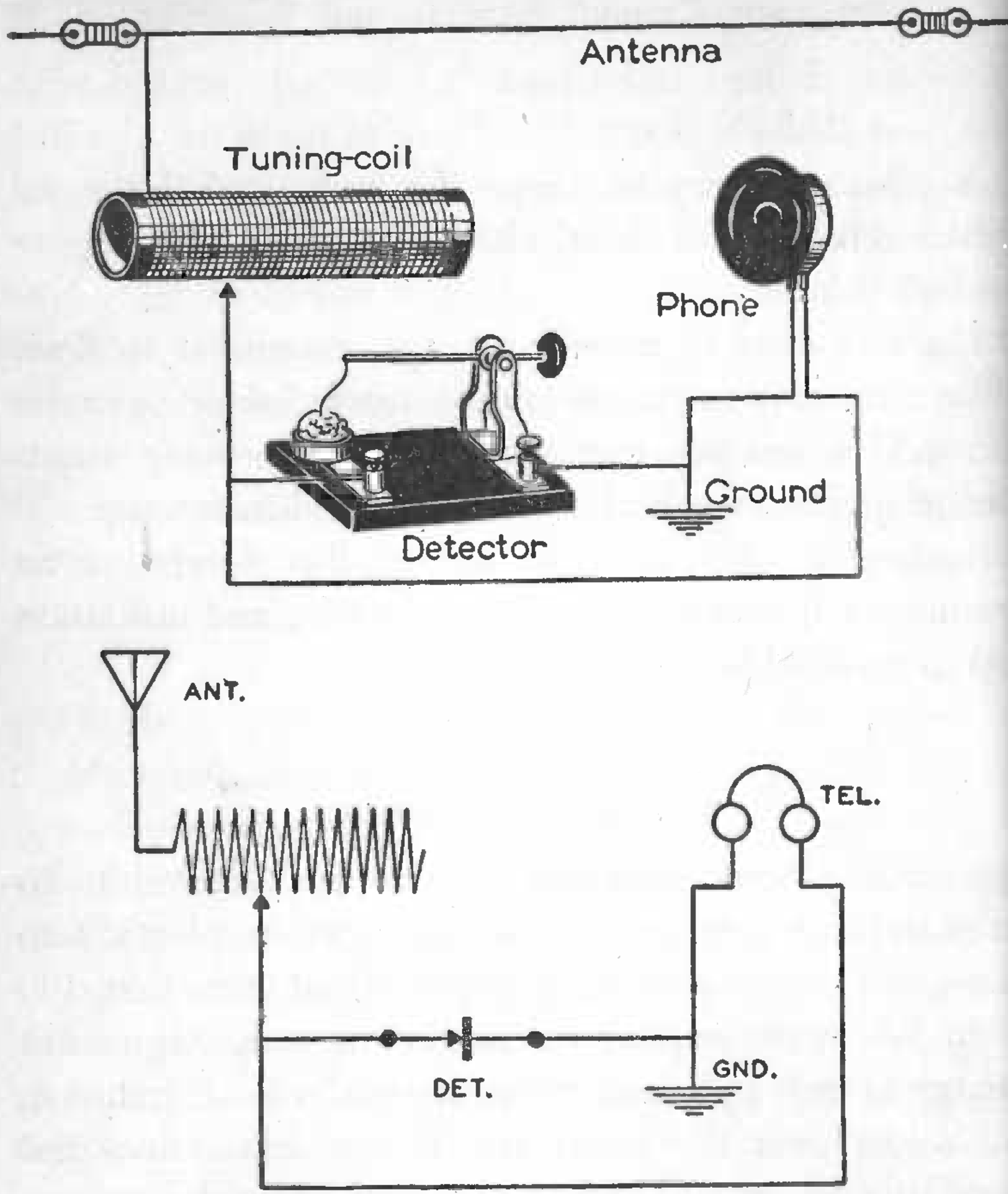
Solder will stick only to bright, clean metal from which all dirt, scale, oxide, and grease have been removed. The terminals of most radio parts are tinned (coated with tin), and solder will usually adhere to them readily. But it may be necessary to scrape the surface of the metal until it is bright and clean. The best tool for this purpose is a knife blade.

The flux used in soldering helps the solder to flow. Rosin is the only flux to use in radio work. Soldering pastes and acid fluxes are corrosive and also provide short-circuits and leakage paths for the tiny radio currents.

Rosin-core solder provides its own flux. Never use an acid-core solder or it will eat into the wire and insulation and cause trouble.

TINNING THE IRON

A small electric soldering iron is most desirable. In order to put a new electric iron into service, plug it into an outlet in a house-lighting circuit of not more than 130 volts. When the copper tip reaches a temperature hot enough to melt a piece of rosin-core solder held against it, rub solder over the entire tip. If the solder does not "flow," that is, spread and form a coating on the copper, file the tip, and as quickly as possible rub more rosin-core solder over it before the tip has had time to change color. This preliminary to soldering is called "tinning the iron," and, needless to say, the iron must be properly tinned before it will solder successfully.



PICTORIAL AND SCHEMATIC DIAGRAMS COMPARED

Here you can compare the pictorial (top) and schematic (bottom) diagrams of a simple radio receiver using a tuning coil and a crystal detector. In both diagrams, the arrow head represents a movable contact or slider. The round black dots in the schematic represent the binding posts on the crystal detector. The black rectangle is the crystal and the arrow head in contact with it represents the cat-whisker.

MAKING A SOLDERED CONNECTION

Wrap the bare, bright end of a wire around the terminal to which it is to be soldered. Hold the hot electric soldering iron firmly against the connection until both the wire and the terminal are hot enough to melt the solder. The solder should spread out or "sweat" into the connection. Hold the iron firmly in one place while soldering. Since it is the solder which flows *between* the wire and the terminal that is of most value in forming the connection, there is no advantage in using so much solder that a ball forms.

Remove the iron and let the connection cool. When cold, test the joint by pulling on it. It should be tight. If a solid joint that can not be pulled apart has not been made, it is because insufficient heat was used or because one or both parts of the joint were not perfectly clean.

An electric soldering iron is, of course, impractical where electric power is not available. An old-fashioned soldering "copper" heated in a stove or by a blow-torch must then be used. Like the electric iron, it must be tinned before it can be used. Whereas an electric iron will automatically raise itself to the proper temperature when operated on the 110–130 volt circuit, the right heat for an ordinary soldering copper is discovered only by experience. The copper must be hot enough to melt wire solder readily, but not so hot that the tinning on the point "burns off."

AVOIDING MISTAKES IN WIRING

When assembling a receiver it is a good plan to go over each wire on the pictorial diagram or plan with a red pencil as that wire is soldered in place on the chassis. Then, no connections will be omitted, and errors in wiring will automatically be non-existent.

All wiring should be kept as short as convenient and placed close to the base.

CHAPTER III

Things You Should Know about the Parts Used to Build Radio Apparatus

YOU DO not need to know anything about radio or electricity in order to assemble any of the receivers and electronic devices described in these pages. It is necessary merely to follow the plans and instructions.

But it will not do any harm to know something about the various condensers, resistors, tubes, and other parts which are used in building radio devices. In fact, by understanding the purpose of each part, you will find it easier to construct and operate your radio apparatus. And it will be much more fun.

Do not let the fact that radio parts are constructed in many different forms and sizes make them seem confusing or mysterious. The principle is always the same, regardless of size.

WHERE PARTS CAN BE OBTAINED

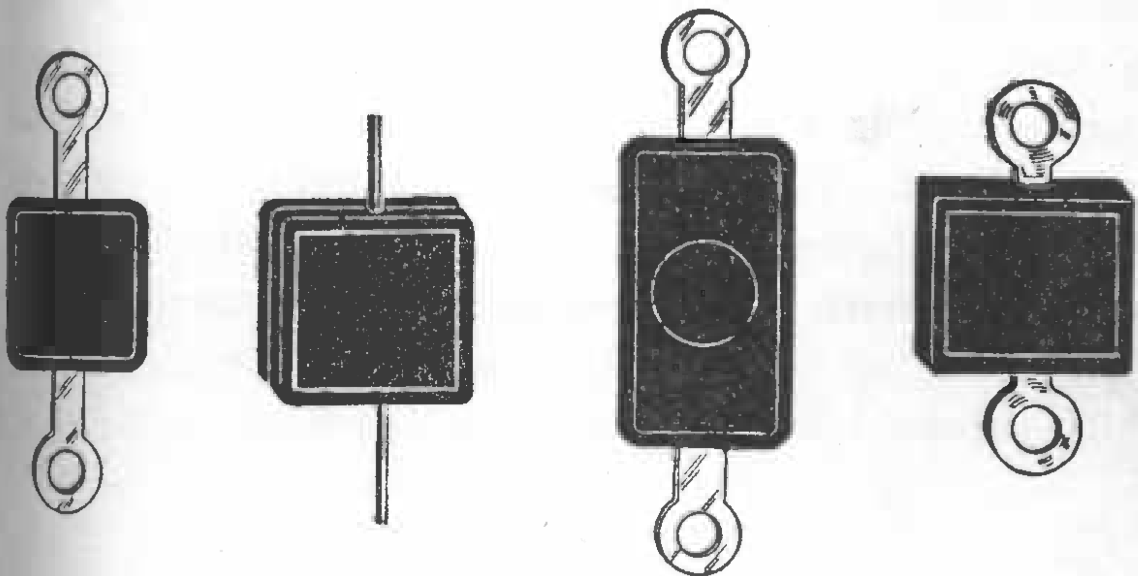
All the parts used in building the apparatus described in this book are standard parts. They are manufactured in large quantities and are inexpensive. Any radio dealer who handles amateur equipment will have them in stock or can obtain them for you in a few days. Send for the catalogues of some of the firms which advertise in the radio and popular scientific magazines. There you will find the various detectors, sockets, tubes, condensers, resistors, and other parts you need. If you wish, you can procure them by mail. Radio servicemen usually keep on hand a large stock of the parts used most frequently in repairing receivers, and can supply condensers and resistors.

CONDENSERS

A condenser is usually part of every radio circuit. Condensers store electricity. They do not store much electricity or store it for long. You need not concern yourself about the manner in which condensers store electricity. For practical purposes, think of them as having the interesting and useful property of allowing an alternating current to pass, but of completely blocking or preventing a direct current from passing.

Two sheets of metal separated by an insulating material called the *dielectric* are a condenser. The insulating material used in radio condensers may be air, waxed paper, mica, or special chemical compounds.

The "size" of a condenser is not considered to be its physical dimensions or its weight but its ability to store electricity. This ability, which is called the *capacity* of the condenser, is indicated or measured in *microfarads* and *micro-microfarads,* the abbreviations for which are *Mfd.* and *Mmfd.* Condensers are usually marked to show



MICA CONDENSERS

The size and shape of these condensers vary considerably but the electrical principle is always the same. Any type will be satisfactory provided it has the proper capacity, as called for in the wiring diagrams and lists of parts. The capacity of the condenser is marked upon it in figures or by color code. If you buy small condensers which are color coded, ask the dealer to give you a memo showing the capacity of each condenser and identifying it by its color markings.

their size. It is important to use condensers of the proper capacity in a radio circuit.

FIXED CONDENSERS

Condensers are of the fixed or the variable type, according to whether the capacity is variable or not. Fixed condensers are made in a great variety of shapes and sizes. The smallest sizes usually have a mica dielectric, the intermediate sizes use paper, and the largest capacities employ a film of chemical compound.

BY-PASS CONDENSERS

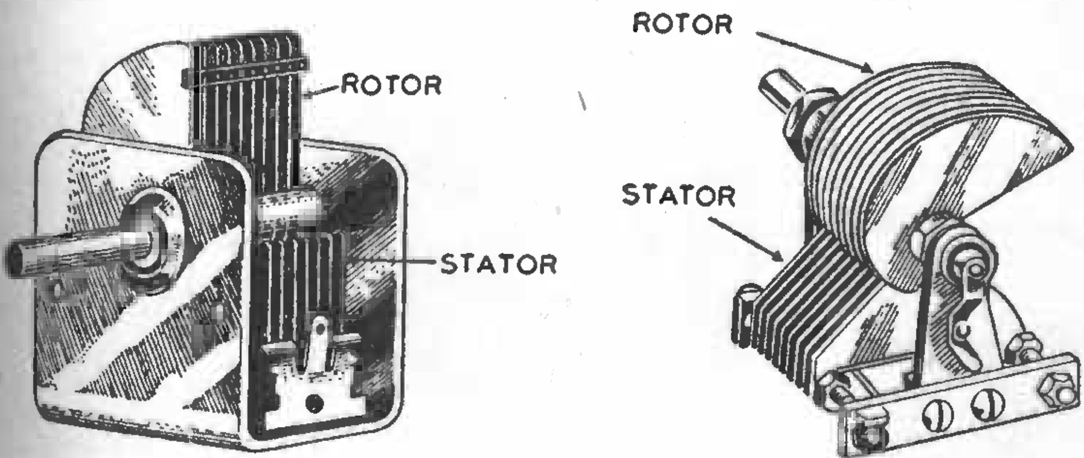
Most paper by-pass condensers have one terminal marked "ground" or "outside foil." When a circuit diagram shows a fixed condenser connected to the ground, the terminal marked "outside foil" or "ground" should be connected to the ground or to the chassis. When grounded thus, the outside foil shields the inside foil which is the high-potential or "hot" part of the condenser.

DRY ELECTROLYTIC CONDENSERS

The terminal wires of a dry electrolytic condenser are red and black. The red wire is positive and is sometimes marked "positive" or plus. When connected in a circuit the polarity must be observed as marked.

VARIABLE CONDENSERS

The most common type of variable condenser consists of a number of movable, semi-circular metal plates which rotate between a group of rigid or fixed plates so as to interleave. The air in the space between the plates is the dielectric. The capacity is varied by turning a knob which rotates the movable plates. The group of movable plates is called the *rotor*. The group of fixed plates is called the *stator*. In some instances a circuit diagram or the instructions indicate the stator of a variable condenser and direct that a certain wire be connected to it and not to the rotor. This is important and is done to avoid the effect of "hand" or "body capacity" when tuning the re-



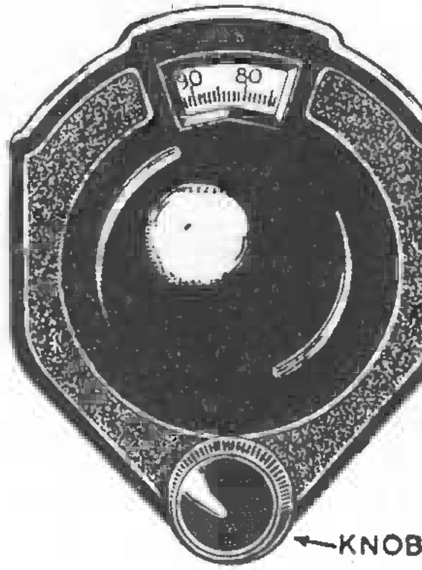
VARIABLE CONDENSERS ARE USED FOR TUNING

Variable condensers differ slightly in the details of their construction but they all operate on the same principle. The rotor is the group of movable plates attached to the shaft. The stator is a group of fixed plates supported by but insulated from the frame of the condenser. The rotor and the frame are electrically connected. In order to avoid what is known as "body effect" caused by moving the hand to or from the tuning-knob, the rotor and the frame of a variable condenser are always grounded to the chassis or ground plate on a receiver.

ceiver. Otherwise, the movement of the hand to and from the tuning knob will affect the tuning.

The variable condenser used in building any of the apparatus described in this book should be provided with a dial, so that you can take note of the position of the condenser where certain stations are heard. A vernier dial for making a very close adjustment of the variable condenser is desirable when tuning short waves. A vernier dial is geared so that turning the knob a considerable distance moves the condenser plates only slightly.

The "trimmer condensers" sometimes used in the antenna circuit of amateur-built receivers are "adjustable"



VERNIER DIAL

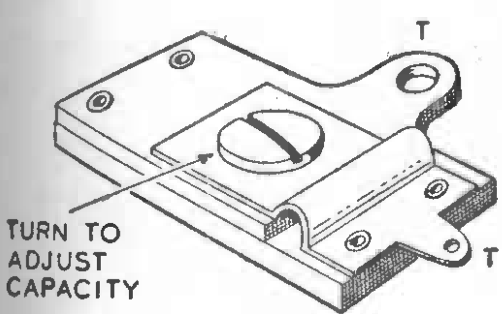
A vernier dial is geared so that the knob must be turned a considerable distance in order to move the condenser rotor a very small distance. A vernier dial for making a very close adjustment of the variable condenser is desirable when tuning short waves. The dial illustrated above has a 9 to 1 ratio and costs 40 cents.

condensers rather than variable condensers. Their capacity is adjustable and may be varied by using a screwdriver to turn a screw which moves the two plates closer together or farther apart.

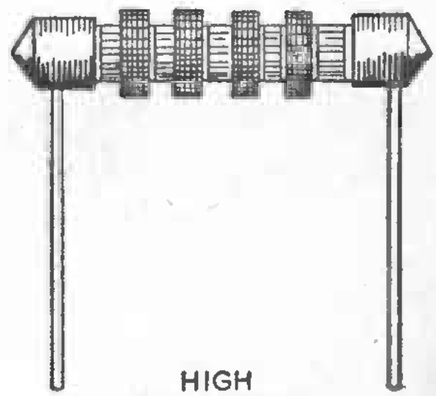
INDUCTANCES

The word *inductance* has a great deal of meaning to the radio engineer. Part of its mystery can be removed from the mind of the young radio experimenter if he thinks of an inductance as a coil. Inductances are often called inductance coils. They are constructed in many forms, sizes, and shapes. The tuning coil in the simple radio receiver illustrated on page 67, described in Chapter IV, is an inductance.

The effect of an inductance coil in a circuit is just the



TRIMMER CONDENSER



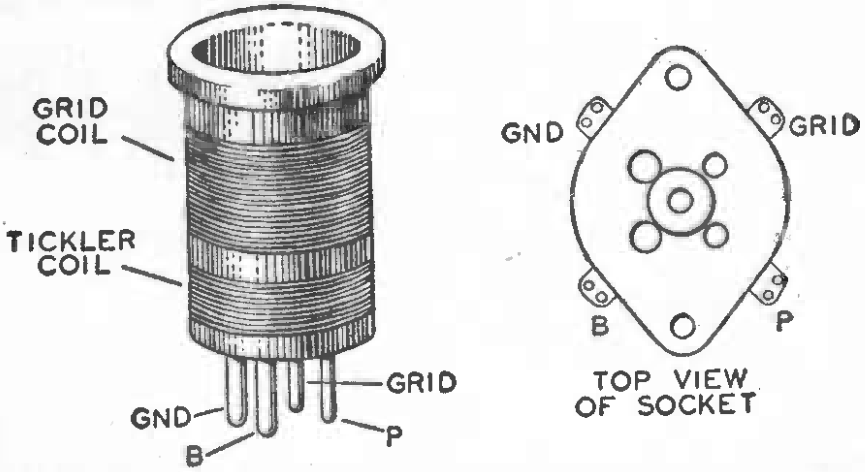
HIGH FREQUENCY CHOKE

These are two of the parts needed to build the one-tube battery set. The terminals of the trimmer condenser are marked T in the illustration. The high-frequency choke is the size designated as 2.5 millihenries.

opposite of that of a condenser. It offers a low resistance to the flow of direct current, but high resistance to the flow of alternating current. A variable inductance may be used to tune radio circuits.

An important electrical phenomenon takes place when condensers and inductances are used together in a circuit. Used separately, condensers and inductances offer varying amounts of resistances to alternating currents, used together in just the right proportion the resistance of the combination to the passage of an alternating current is at a minimum and the voltage is at a maximum value. By combining inductance coils and variable condensers, we are able to tune our circuits to a desired fre-

4-PRONG PLUG-IN COIL AND SOCKET



Those amateurs who have had considerable experience in building radio apparatus can wind their own plug-in coils. The novice should purchase them ready made. The prongs on the coil and the terminals of the socket are marked in the illustration to correspond with the markings used in some of the wiring diagrams.

quency, thus selecting a particular program. Or, in the case of a transmitter, to send out a wave of the desired length.

The inductance coils used in the receiving apparatus —utilizing crystal detectors—described in these pages are home-made. The "plug-in" coils used with the receiving apparatus which employ a radio vacuum tube as a detector are best purchased. It costs at least as much to buy the forms and the wire as it does to purchase the completed coils.

Standard plug-in coils for use in receiving sets usually have either four or six prongs. The four-prong coils each consist of two windings, wound on molded Bakelite forms approximately 1¼ inches in diameter and 2¼ inches high. Six-prong coils consist of three windings. Five-prong coils are used sometimes. They consist of two windings, one winding being tapped.

The prongs on the bottom of the Bakelite form are the terminals of the windings and fit the standard four-prong and six-prong tube sockets.

A kit of four four-prong coils, covering from 9.5 to 200 meters when tuned with a .00014 Mfd. variable condenser, can be purchased for as little as eighty-five cents. A set of two coils covering 100 to 570 meters can be purchased for sixty-five cents.

WIRE

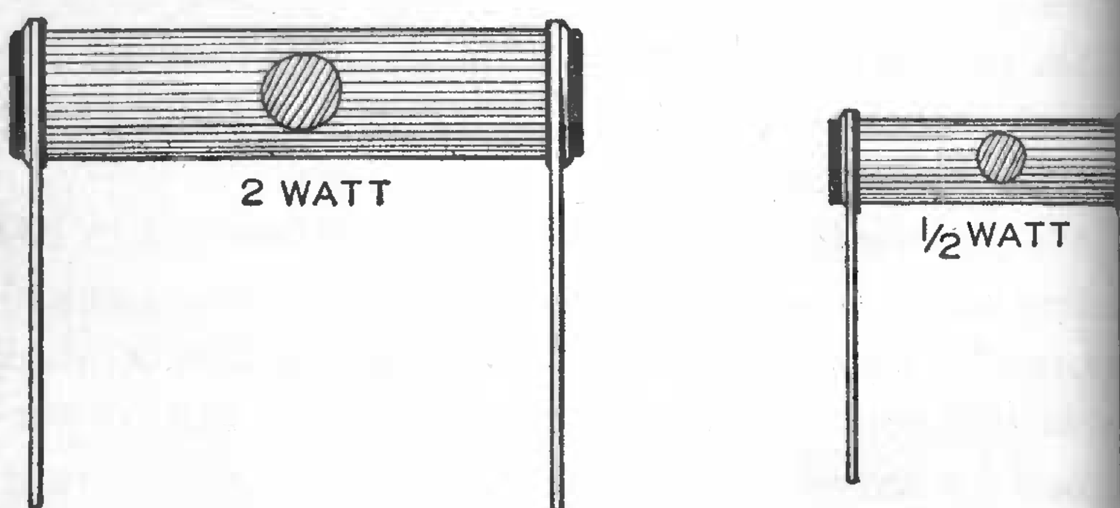
Magnet wire for making your own plug-in coils or for winding the tuning coils or inductances used in building a crystal detector set can be obtained from any firm that supplies amateurs and radio servicemen. It is usually sold on wooden spools in ¼-pound or ½-pound lots. Plain enameled wire is used unless the directions specify otherwise.

Push-back wire (solid tinned, No. 20 B. S. gauge copper) may be obtained from any radio serviceman.

RESISTORS

Resistors are required in many radio circuits. They are devices for opposing the flow of electricity. Principally they are used to reduce the voltage in a circuit.

The ability of a resistor to oppose the flow of electricity



RESISTORS

Small resistors like those shown above find wide use in modern radio receivers. You can identify the size or capacity of a resistor by its size, and its value or resistance by its colored markings.

is called its *resistance* or *value* and is measured in ohms. Resistors are made in a great many values. The amount of energy which a resistor will carry indicates its size.

The small sizes, usually ¼-watt or ½-watt, are used in receiving circuits. A two-watt resistor is larger than a ½-watt resistor. It will carry four times as much energy.

A 10-ohm resistor offers twice as much opposition to an electric current as a 5-ohm resistor.

Resistors may be either fixed or variable. Fixed resistors are usually cylindrical and have tinned wire terminals.

Small resistors are inexpensive. They sell for three to ten cents each. You can identify the size of a resistor by its dimensions, and its value or resistance by its colored markings.

When building your own radio sets you will need to check the resistance value of each resistor before you solder it in place.

THE COLOR CODE FOR RESISTORS

The Radio Manufacturers' Association have adopted color codes for marking resistors so as to indicate their resistance.

Small resistors (½-watt and one-watt) are marked with colored stripes which indicate their resistance. Ten colors are used. Each color represents a number or figure. The *End* band or stripe represents the first figure of the resistance. The second stripe indicates the second figure and the third stripe shows the number of ciphers.

Resistors sometimes have a fourth colored stripe to indicate the *tolerance* or accuracy of the resistance indicated by the color bands. A gold stripe means that the resistance may vary five per cent more or less than the value indicated by the bands. A silver stripe means that

COLOR CODE FOR ½-WATT AND 1-WATT RESISTORS

End Stripe (First Figure)		*Second Stripe* (Second Figure)		*Third Stripe* (No. of Ciphers)	
Black	0	Black	0	Black	none
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0000
Green	5	Green	5	Green	00000
Blue	6	Blue	6	Blue	000000
Violet	7	Violet	7		
Gray	8	Gray	8		
White	9	White	9		

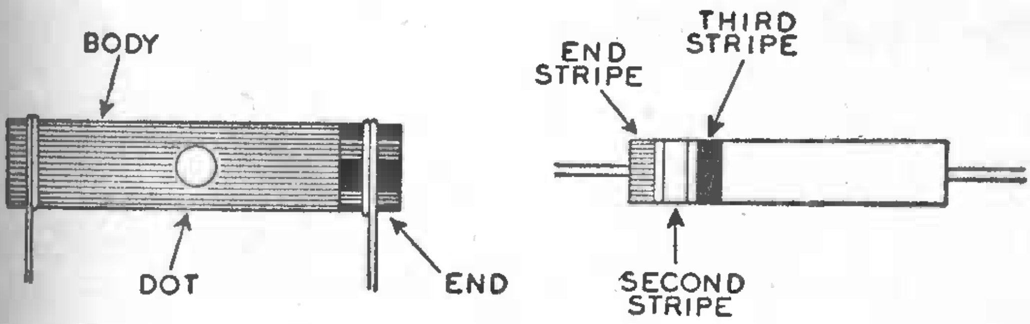
the resistance may vary ten per cent more or less than the value indicated by the bands.

The end stripe or band on a resistor of 10,000 ohms is brown (1). The second stripe is black (0) and the third is orange (000). A fourth stripe of gold would mean that the actual resistance may vary between 9,500 and 10,500 ohms. A fourth stripe of silver would indicate that the actual resistance may vary between 9,000 and 11,000 ohms.

In marking two-watt resistors a slightly different plan is used. Instead of stripes or bands, the color of the body of the resistor, the end color and the color of the dot at the center each have a meaning.

The color of the body indicates the first figure of the resistance. The end color indicates the second figure, and

RMA RESISTOR COLOR CODE



2 WATT   ½ & 1 WATT

The colors used in marking the body, dot, and end of 2-watt resistors indicate their value. Small resistors (½-watt and 1-watt) are marked with colored stripes which indicate their resistance. The color code used in these markings will be found in the text.

the color of the dot on the center of the body indicates the number of zeros which follow.

Color Code for 2-Watt Resistors

Body (First Figure)		*End* (Second Figure)		*Dot* (No. of Ciphers)	
Black	0	Black	0	Black	none
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0000
Green	5	Green	5	Green	00000
Blue	6	Blue	6	Blue	000000
Violet	7	Violet	7		
Gray	8	Gray	8		
White	9	White	9		

For example, a resistor with a yellow body, black ends, and an orange dot would check as follows:

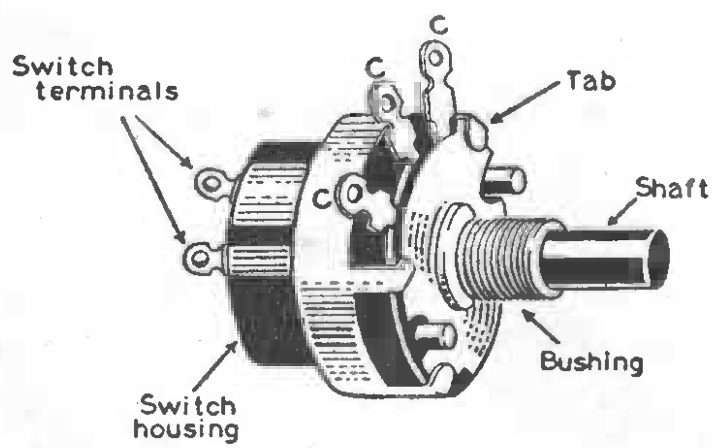
Yellow Body	*Black Ends*	*Orange Dot*
4	0	000

or 40,000 ohms.

RHEOSTATS AND POTENTIOMETERS

Rheostats and potentiometers are variable resistors provided with a knob. Turning the knob varies the resistance.

Potentiometers and volume controls are alike. They have three terminals and are used to control voltage. A rheostat is most often used in radio circuits to control the



REGENERATION CONTROL

The potentiometers, volume controls, and regeneration controls used in radio sets are one and the same thing. They have three terminals and are used to control voltage. The terminals of the control illustrated above are marked "C." The back of the control is fitted with a switch which turns the tube filament current on and off. To fit a control of this type with a switch, remove the metal cover and put the switch in its place.

ırrent flowing through the filaments of the vacuum bes. Usually a potentiometer is employed to control the ›lume or loudness of the signals. It does this by regu- ting the voltage in a certain part of the circuit.

In this book, potentiometers are used in some of the ceivers to control what is known as the regeneration of e detector tube.

FILAMENT LIGHTING SWITCH

Potentiometers designed to be used as a volume con- ol are constructed so that they can be fitted with a switch, hich turns the filament lighting current on and off. It is erely necessary to remove the metal cover on the po- ntiometer and put the switch in its place.

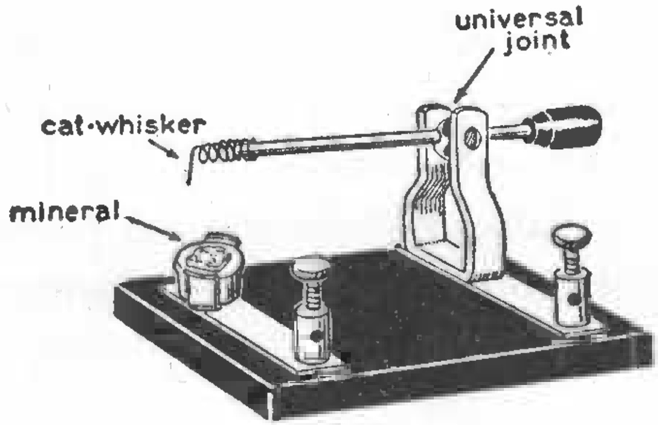
CRYSTAL OR MINERAL DETECTORS

A detector is part of every radio receiver. The simplest etector is a piece of certain sensitive crystal or mineral.

A crystal or mineral detector—both names are used— not as sensitive or as satisfactory as a vacuum-tube de- ctor. It is, however, simpler, less expensive, and easier construct, and it provides the best way of becoming ac- uainted with radio. With nothing more than a suitable ystal and a telephone receiver connected to an antenna d ground, radio messages can be received.

There are a number of substances which make satis- ctory crystal detectors, but galena is most commonly used. Galena is a natural lead ore found in the earth in beds or veins or crystalline rocks. It has a luster similar to silver and forms in cubical crystals which split and break into smaller cubes.

A piece of galena or other crystal suitable for radio use acts as a *rectifier;* that is, a current of electricity will flow through it in one direction better than in the other. A



A CRYSTAL DETECTOR

A complete crystal detector like that above can be purchased for fiftee cents. It comes equipped with a crystal, but it is best to replace this with more sensitive *tested* crystal.

sensitive piece of galena will pass ten times more curre in one direction than it will in the other. It acts as a so of electrical check valve. No satisfactory explanation h been found for how or why certain crystals act as an ele trical valve.

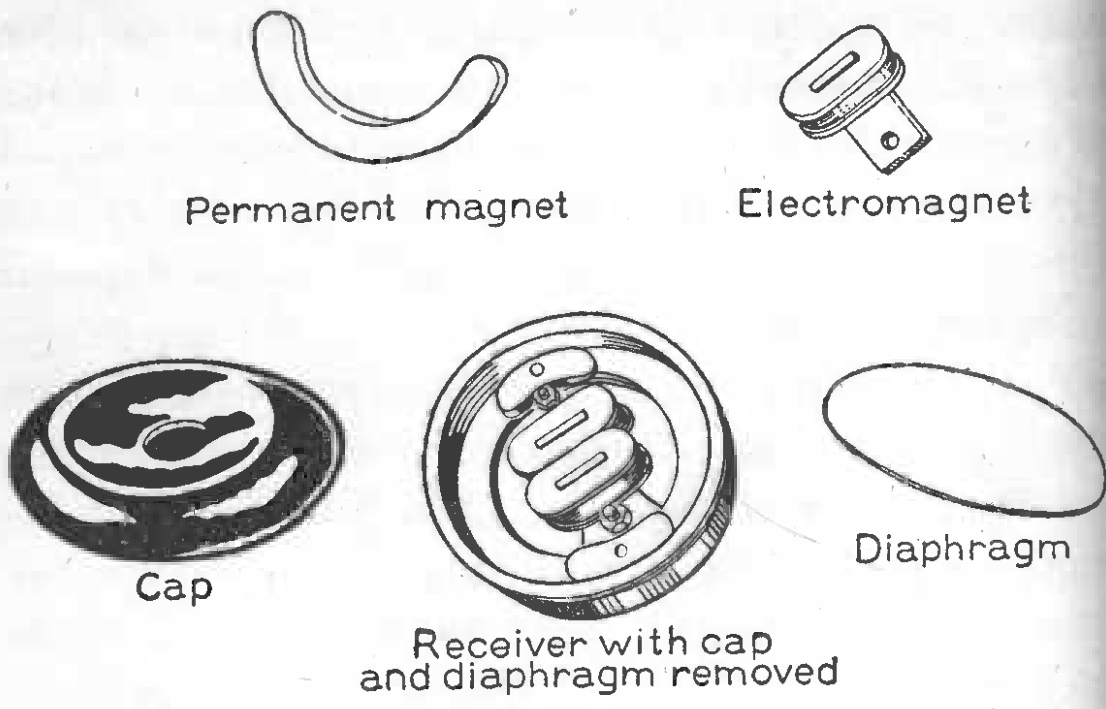
In order to be most efficient as a radio detector, a pie of sensitive galena is mounted in a clamp or a cup, or s in a slug of metal having a low melting point. A fine wi called a "cat-whisker" is brought to bear on a sensitive spot on the exposed surface of the mineral. Usually the fine wire forming the cat-whisker is mounted on a swivel arm moving in a ball and socket so that the "whisker" can be brought into contact with any point on the exposed surface of the crystal.

Crystal detectors may be purchased ready-made from radio dealers who handle parts for amateurs and experimenters. They are inexpensive. The "fixed" crystal detectors are convenient because they do not require any adjustment, but they are not as a rule as sensitive as those which you can adjust yourself. You can, if you wish, make your own crystal detectors. Instructions for doing so are given in another chapter.

TELEPHONE RECEIVERS

The telephone receivers used in radio are the round flat form called "watch-case receivers," which may be held against the ear by means of a head-band.

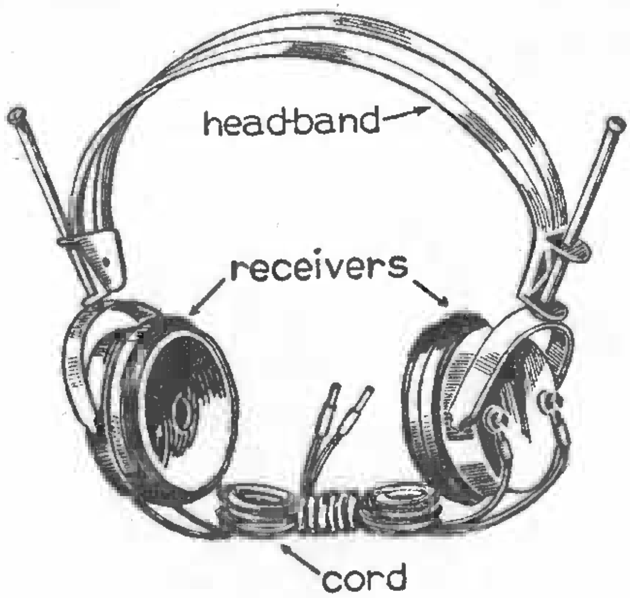
They do not differ in principle from the ordinary telephone receiver. They consist of a sheet-iron diaphragm close to two small electromagnets mounted upon a permanent magnet. The permanent magnet exerts a pull upon the diaphragm. A current of electricity flowing through the electromagnets changes the pull on the diaphragm and causes it to move. When the diaphragm moves it produces sounds.



INSIDE A TELEPHONE RECEIVER

If you have a good radio headset take care of it. Don't drop it and don't take the caps off the receivers. Keep the caps screwed on tightly. If you "monkey" with the diaphragm of a telephone receiver, you may bend it. If the diaphragm is not perfectly flat, the receiver will not be sensitive. When you want to know how it is made, don't take your receiver apart. Look at this picture instead.

The ordinary telephone receiver has a resistance of about seventy-five ohms. The resistance of a telephone receiver made for radio use is very much higher. There is a good reason for this. If the electromagnets are wound with fine wire, the receiver will respond to smaller currents than it will if wound with coarse wire. Since the electrical currents flowing in a radio receiving set are very small, the telephone receivers for changing them into sounds must be wound with fine wire. Fine wire has considerable resistance. A radio head-set (two receivers with head-band) usually has a resistance of 2,000 to 3,000 ohms and is so sensitive that it will respond to the almost



TAKE GOOD CARE OF YOUR RADIO HEADSET

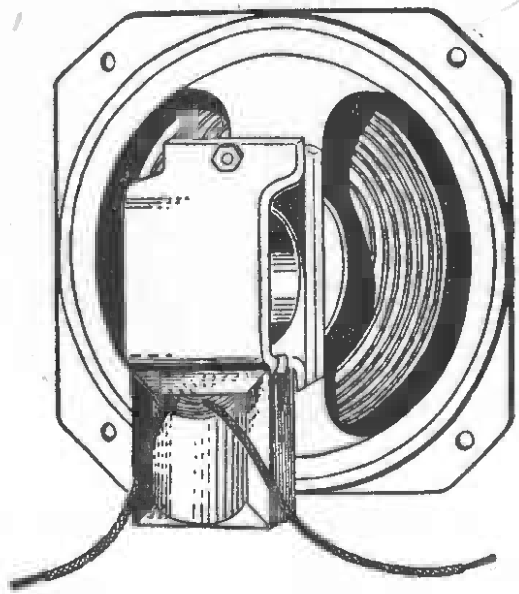
An amazingly small amount of electrical energy flowing through the coils of a sensitive telephone receiver will produce sounds audible to the human ear. Telephone receivers for radio work are light and small. They are the type commonly known as "watch-case" or "head-phone." A complete radio headset consists of a pair of watch-case receivers fitted with a head-band so that a receiver is closely held to each ear. The receivers are connected in series with each other by a flexible wire called the "cord." The free end of the cord terminates in two metal "tips." These tips are the terminals which you connect to the radio receiver or amplifier.

infinitesimal amount of current generated by touching two wires to the tip of the tongue.

A set of radio head-phones (called "cans" in amateur language) costs from one dollar to ten dollars. Needless to say, a ten-dollar set is much more sensitive and more substantial than one which sells for one dollar. However, it is not necessary to pay the top price to get a good pair.

SPEAKERS

The ordinary speaker is similar to a telephone receiver in principle but is designed to produce sounds so loud



A SMALL PERMANENT MAGNET SPEAKER

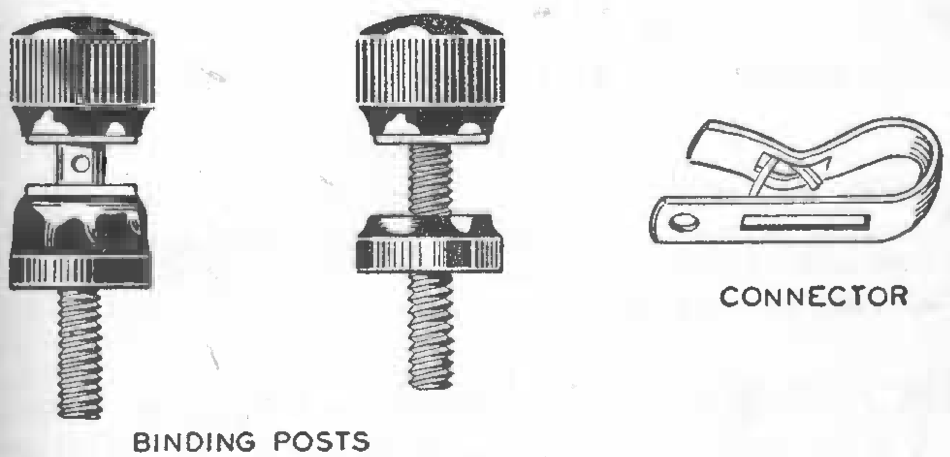
A speaker is quite similar to a telephone receiver in principle but produces louder sounds. The magnetic field, in which the coil or armature attached to the speaker moves, is established by a permanent magnet or a coil. The smaller sizes of speakers utilize a permanent magnet. Use a 4-inch permanent magnet speaker in the 2-tube A.C.–D.C. Receiver. The same size will perform well when connected to either of the amplifiers described in this book. You can, if you wish, use a larger speaker with the 2-tube amplifier.

that a group of people can listen to the same receiving equipment. Instead of the sheet-iron diaphragm of the telephone receiver, the speaker uses a paper cone.

In the dynamic type of speaker a small coil of very fine wire, called the voice coil, is attached directly to the cone. This coil is supported in the field of a powerful magnet. When a current is sent through the coil, the coil moves and moves the cone-shaped diaphragm. When the diaphragm moves, it produces sounds. A speaker is not as sensitive as a telephone receiver. It requires stronger currents. Before the currents in a radio receiver will operate a speaker, they must be strengthened by passing through an amplifier.

BINDING POSTS

There are several types of binding posts suitable to use on a radio set, some of which are illustrated near-by. Instead of using binding posts for connecting the telephone receivers to a radio set, it is more convenient to use a double "tip jack." The cord tips push in or out and are secured, gripped by contact springs.

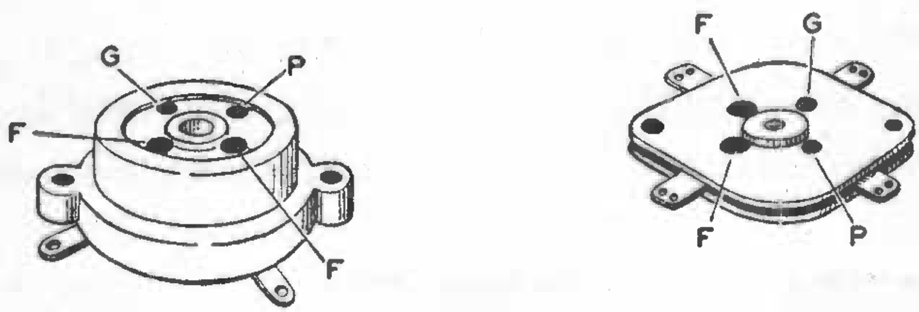


BINDING POSTS

Two types of binding posts suitable to use on a radio set are illustrated. At the right is a connector often used in place of binding posts.

SOCKETS

Sockets for radio vacuum tubes are made in many different patterns. The inexpensive wafer type sockets are satisfactory for the receivers described in this book. They are made to fit four, five, six, seven, and eight prong tubes.



BASE MOUNTING SOCKET   WAFER SOCKET

TUBE SOCKETS

Here are the two most common types of radio-tube sockets. The wafer socket is used in the apparatus described in this book because it costs less than the base mounting variety. If you can afford them, use the base mounting type. They make a neater job.

The seven-prong models are made in two sizes: small and large. A socket must be of the proper size and type to fit the tube for which it is intended.

In order to mount a wafer socket on a baseboard it is necessary to use a spacer at each end. Suitable ½-inch brass spacers cost about one cent each. These will raise the socket sufficiently to accommodate the contacts and tube prongs.

LINE CORD RESISTORS

Small radio receivers made for operation on the 110-volt lighting circuit, without using a filament transformer, employ a line cord resistor. The resistance necessary to reduce the 110-volt current so that it will not burn out the tube filaments is contained within the flexible cord. There are three wires within the cord. They are usually colored white, black and brown, or red. The white one is usually the resistance wire. The red or brown wire together with the white deliver current which is reduced by the resistance. The red or brown together with the black then deliver the full 110-volt current.

Line cord resistors are made in different sizes ranging in resistance from 135 ohms to 360 ohms. It is necessary to obtain a line cord resistor of exactly the resistance specified for each receiver. No other one will do. Never cut or shorten a line cord resistor. This would change its resistance.

When wiring a radio receiver, ascertain which wire contains the resistance. Connect the line cord resistor exactly as indicated in the wiring diagram. Not to do so would mean that the receiver would not operate and that you might burn out your vacuum tubes.

THE HOW AND WHY OF THE RADIO VACUUM TUBE

The radio vacuum tube is one of the most amazing scientific developments of the past three decades. Not only is it the heart of all radio apparatus for both transmitting and receiving, but practically every branch of industry is finding uses for its services.

This simple device makes it possible to control large electrical energies by means of small energies. In that way it is like a lever used to control mechanical power. A small amount of energy in the fingers applied to a switch or lever can stop or start a motor or engine and control a large amount of power. A small amount of electrical energy applied to the "grid" of a vacuum tube can control a larger amount of electrical energy flowing in a circuit to which the "plate" and "filament" of the tube are connected.

In order to build your first radio apparatus, you will not need to know how a vacuum tube operates. But here is an explanation for those who wish it.

ELECTRONS

Electronics is the name of the art and science to which vacuum tubes belong. In it is a clue to how and why a radio vacuum tube behaves as it does. The name was applied because the tube utilizes a stream of *electrons*.

Electrons are tiny particles of negative electricity. An electric current is an orderly procession of tiny, invisible electrons.

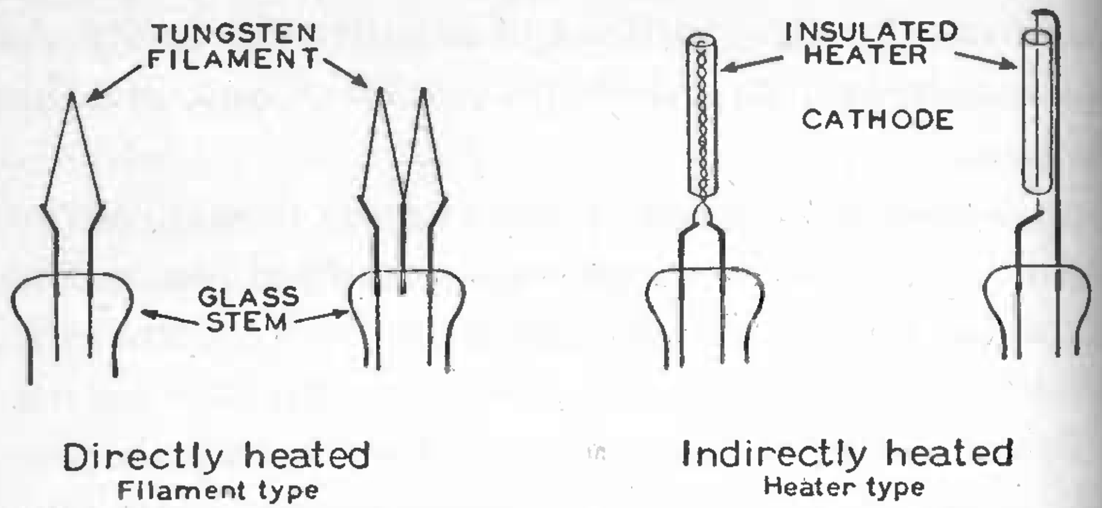
When an electric current pushes its way through a wire, it heats the wire. If the electrons are crowded because the wire is too small to accommodate the procession easily, sufficient heat may be developed to make the wire red hot. In that case some of the electrons leave the crowded wire and fly out into space. Knowing this, we can pry into some of the secrets of a radio tube.

INSIDE A RADIO TUBE

Inside every radio tube is a wire *filament* which becomes red hot when a current passes through it, a small wire screen or grating called the *grid,* and a metal plate or cylinder called the *plate.* The grid is placed between the filament and the plate.

The purpose of the filament is to become hot and produce electrons. If the electrons are thrown off directly by the filament, the latter is called the *cathode.* The word cathode is used frequently in radio. It means negative. Think of a little minus sign whenever you think of cathode and you will remember what it means.

The plate in a vacuum tube is frequently called the *anode.* Anode means positive. Think of a plus sign when you think of anode. A radio tube is always so connected



INSIDE A RADIO TUBE

A radio tube is one of the most interesting and useful inventions of the twentieth century. In order for a radio tube to function, it must produce a small cloud of the tiny particles of electricity called *electrons*. The electrons are produced by a hot *cathode* inside the tube. The cathode is kept hot by an electric current. The cathode in a tube designed to be operated on a battery is a filament of tungsten wire like the filament in an incandescent lamp. It is called a directly heated cathode and is shown at the left in the illustration above. The cathode in a tube designed for alternating current is a chemically treated sleeve surrounding and kept hot by a tungsten filament called a *heater*. A directly heated cathode produces a humming noise in a receiver if operated on alternating current but an indirectly heated or heater-type cathode does not.

in its circuit that the cathode of the tube is negative and the plate or anode is positive.

Some radio vacuum tubes are intended to have their filaments heated by direct current, the kind that flows steadily in one direction. In that case, the electrons thrown out by the hot filament wire are utilized and the filament itself is the cathode.

Radio tubes are also made so that alternating current can be used to heat their filaments. In that case, the electrons from the filament are not utilized. The filament is merely the *heater* of a chemically prepared cylinder which throws out the desired electrons and acts as the cathode. This method of construction is necessary in order to prevent the "hum" which would otherwise be produced in the circuits by alternating current.

HOW THE TUBE OPERATES

By connecting a vacuum tube in a radio circuit so that the plate is positive, the electrons thrown off by the cathode are drawn to the plate. As they travel to the plate, the electrons pass through the grid.

We have now come to the vacuum tube's main secret. The grid is a sort of barrier or gate. It can allow the electrons to pass on their way to the plate or it can repel them —push them back and prevent them from going through.

If the grid is charged with positive electricity, it will allow the electrons to pass to the plate. If it is charged with negative electricity, it will repel the electrons, driving them back toward the filament.

A very small change in the charge on the grid will make a large change in the electrons traveling across the space from the cathode to the plate. A radio vacuum tube will respond to so feeble a change in the charge on its grid that it is one of the most sensitive instruments known to science.

If the grid is connected to an antenna, and the cathode and the plate are made part of a circuit containing a battery and a telephone receiver, the arrangement will receive radio signals.

CHAPTER IV

Building Your First Radio Set

If you have never built any radio apparatus and would like to experiment, here is good advice. Begin your radio adventures by building a receiver with a crystal detector. This does not require much time, will cost little, and will teach some useful radio principles. It is probably the best way to become acquainted with radio. Building a receiver with a crystal detector is an experience which will make the construction of a receiver with a vacuum tube detector seem simpler.

Crystal detectors are not as sensitive as vacuum tube detectors. Usually, they will not pick up signals from as far distant stations as will a vacuum tube.

If you live within twenty-five to fifty miles of a broadcasting station, you can listen to its programs with a crystal detector and a simple tuning coil.

If you live more than fifty miles away from the nearest radio transmitter, it will be necessary to build a more elaborate set, one tuned with a variable condenser as described later in this book.

HOW TO BUILD A SIMPLE CRYSTAL SET

The following parts are required:

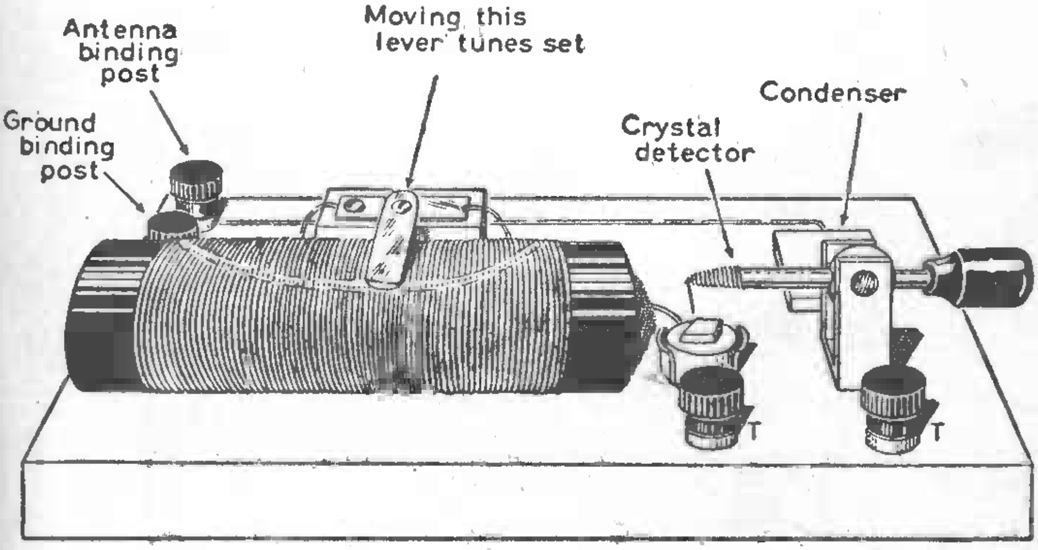
1 Wood base 7″ x 4″ x ½″
1 .004 Mfd. mica fixed condenser
50 ft. No. 27 B. S. gauge enameled magnet wire
1 1,000-ohm telephone receiver or radio head-set
4 Binding posts
1 4″ x 1″ core for tuning coil
Various screws, slider, etc.

It is not important to use any particular variety of wood in making the base of the receiver. It must be dry and preferably shellacked or varnished.

The tuning coil consists of 150 turns of No. 27 B. S. gauge enameled magnet wire wound in a single layer on a core 4 inches long and 1 inch in diameter. This core may be a cardboard tube or a piece of wooden dowel. In either case, before the core is used, it should be dried in a warm oven (not hot) to drive out all moisture. After drying, it should be shellacked or varnished so as to seal all pores and prevent moisture from being absorbed again. This treatment not only will make the core a better insulator but will prevent the core from shrinking or expanding with changes in humidity and temperature, causing the wire to loosen.

Cotton- or silk-covered magnet wire can be used instead of enameled wire but it will not be as easy to scrape the insulation off fabric-covered wire for the sliding contact.

Simple Crystal Set

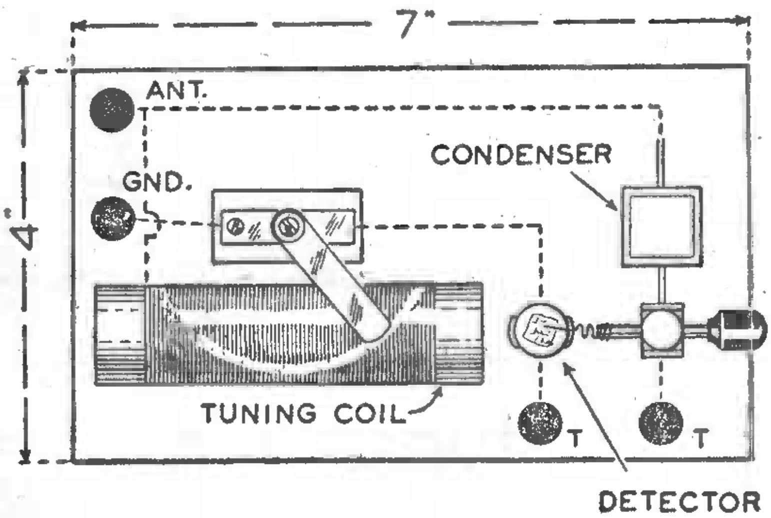


Any boy should be able to build this simple receiver without difficulty. It will teach some useful radio principles. Programs from a broadcasting station 25–50 miles away can be picked up. The binding posts marked T are the terminals to which the phones are connected.

If you have a small lathe, you can mount the core in the lathe and wind the wire on very easily. Do not use power, but turn the lathe by hand, by pulling on the belt. Or you can hold the core against your knee with your left hand and wind on the wire by letting it slip under your right thumb. Turn the core around with your left hand, using your right thumb and forefinger to hold the wire in place when taking a fresh hold of the core with your left hand.

Start the winding about one-half inch back from the end of the core and wind on 150 turns smoothly and tightly in a single layer. There should be no spaces between turns and no turns should overlap. If a single layer of thin wrapping paper is wound around the core before

PLAN OF SIMPLE CRYSTAL SET



The dotted lines represent the wires which connect the various parts. The wire leading from the ANT. post to the end of the tuning coil *crosses* the wire leading from the GND. post to the detector but *is not connected* to it. The head-phones should be connected to the posts marked T. For instructions how to adjust and tune the receiver, see text.

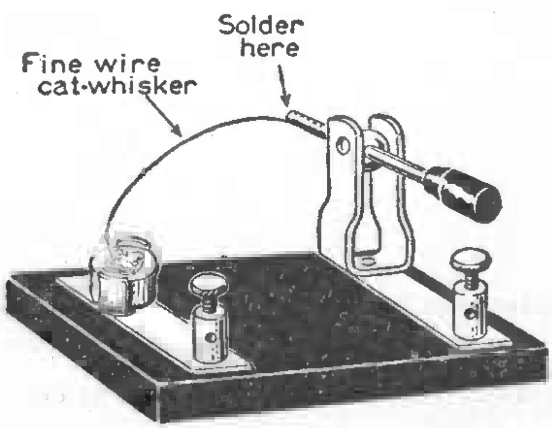
the winding is put on, it will help to prevent the wire from loosening. The ends or terminals of the winding can be fastened by slipping them through two holes drilled through the core. Another good method of securing the terminals is to solder them to two brass nails driven into the wooden core. The enamel insulation can be removed from the wire for soldering by rubbing with a piece of fine emery paper.

Soldering plays an important part in the successful building of radio apparatus. Hold the hot iron firmly against the connection until the solder spreads out or "sweats" into the connection.

Begin your radio adventures by building a receiver with a cryst
detector.

The completed coil is fastened to the wooden base in the position shown in the plan on page 68. Use a brass screw, not an iron one, at each end of the coil; a short screw if the core is a cardboard tube, a long screw if it is a wooden dowel rod.

There are innumerable ways of making a detector stand so that proper contact can be made with the surface of a



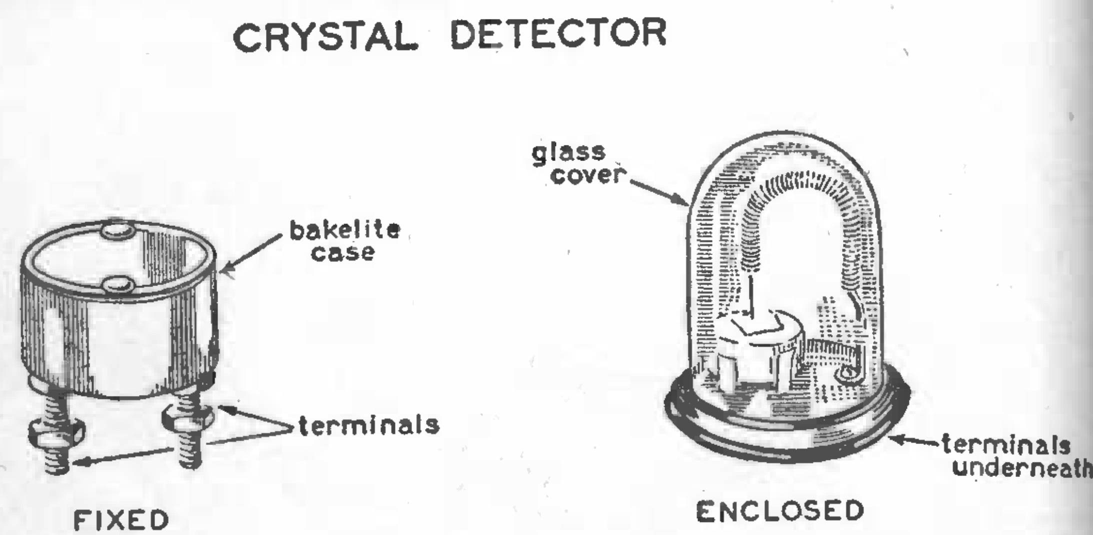
AN IMPROVED DETECTOR

The crystal detector shown above can be greatly improved by the alterations illustrated. The universal joint is turned about at right angles and the small stiff spiral cat-whisker is replaced with a long, flexible one.

sensitive mineral or crystal. From the standpoint of economy, it does not pay to build one. If you wish to build your own crystal detector, you will find instructions in another part of this same chapter.

A detector like that shown above, together with a piece of selected galena mounted in a small slug of low-temperature alloy, is sold for twelve or fifteen cents at many radio shops. The galena crystal which comes with the stand is not as sensitive as a so-called "supersensitive" crystal which can be purchased for ten cents, and it is worth while to purchase and substitute one of these. When crystals become dirty, they lose their sensitiveness, and it is well to have a couple of spares on hand.

A glass-enclosed crystal detector can be purchased for



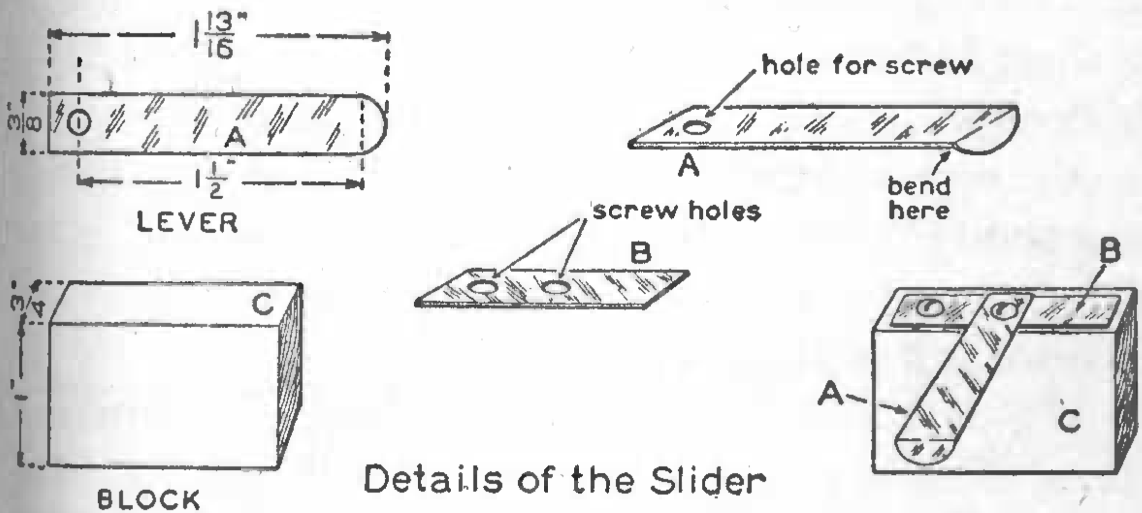
The fixed type of detector has the advantage that it stays in adjustment, but it is not so sensitive as the adjustable type and usually will not pick up messages from distances as great. The glass cover on the enclosed type of detector protects the crystal from dust and dirt.

twenty-five cents. The glass cover protects the surface of the crystal from dirt.

"Fixed" detectors are factory-built devices in which the fine contact or "cat-whisker" is fixed permanently to a sensitive spot on the crystal and enclosed in a molded plastic case with terminals on the bottom. They may be purchased for forty-five or fifty cents. A "fixed" detector is not so sensitive as the best of the non-fixed type but sometimes it is an advantage to have a detector which can not be thrown out of adjustment.

Whether you buy a detector or make your own, it should be mounted on the wooden base as shown in the plan.

The tuning coil is adjusted by a switch lever or "slider." Make this according to the shape and dimensions shown



HOW TO MAKE THE SLIDER

The slider is actually a small switch. The tip of the switch blade slides over the wire wound on the tuning coil and makes contact with each turn as it passes. You can cut the metal parts of the slider out of thin sheet metal with a pair of tinner's snips. The holes are drilled with a small hand drill. Notice how the tip of the switch blade is rounded and bent so that it will slide easily.

in one of the illustrations. It should be cut out of spring copper or brass about .016 inch thick. This thickness is the same as the diameter of the wire used in winding the tuning coil. Tinned sheet-iron cut from a tin can may be used in place of sheet brass or copper in making the lever, but it will not make such a good electrical contact with the wire on the tuning coil.

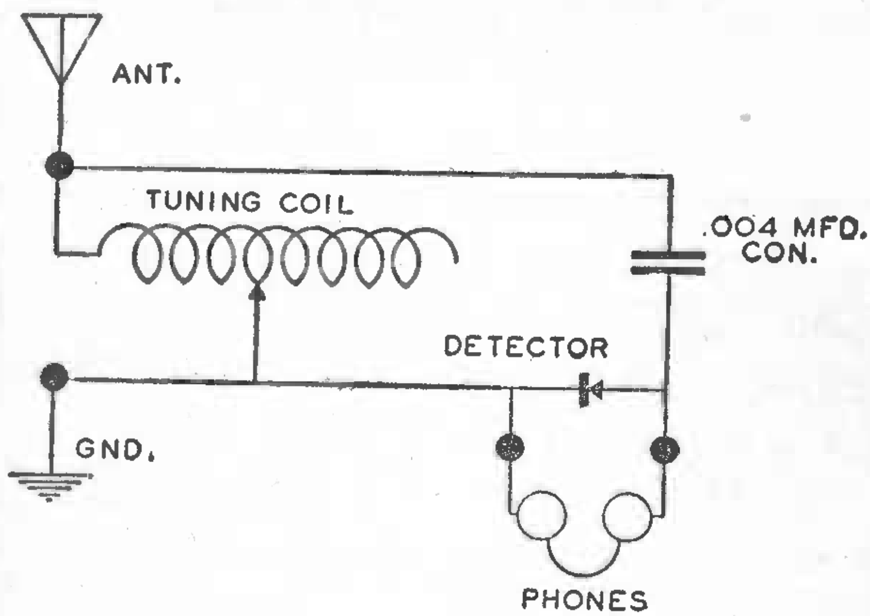
The lever pivots or swings on a wooden block mounted on the base at the rear of the tuning coil. It can be moved easily with the fingers, and as it is pushed to the left or right, the point of the lever should slide over the winding and make contact with each turn of wire except those for a short distance at each end of the coil. The point of the slider will scratch a curved line in the enamel insulation on the wire, and this path should be widened slightly with the point of a penknife. It is essential for the point of the lever to establish a good electrical contact with each turn of wire as it rests upon it.

The .004 Mfd. mica condenser should be purchased from a radio dealer. The cost is small, usually about twenty-five cents. When the condenser and the binding posts are mounted on the base, the receiver is ready to be wired. The ANTENNA and GROUND posts should be located at the rear left-hand corner. The two PHONE posts should be located in front of the detector.

The dotted lines in the plan represent the wires which connect the various parts. By studying the plan and the schematic wiring diagram you should be able to wire the receiver without any difficulty. Use push-back wire and solder all connections.

Connect one end of the tuning coil to the ANTENNA binding post. The other end of the tuning coil is lef "open," which means that it is not connected to anything. Run a wire from the ANTENNA binding post to one terminal of the fixed condenser. Connect the other ter-

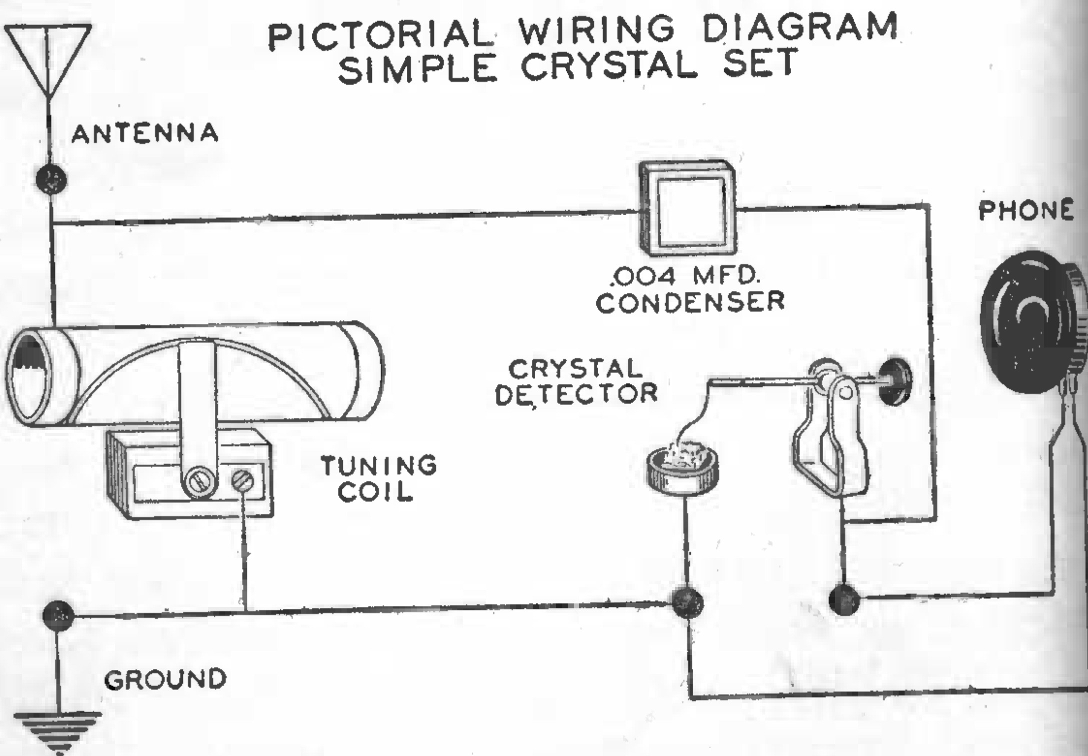
SCHEMATIC WIRING DIAGRAM
SIMPLE CRYSTAL SET



This diagram, together with the pictorial diagram shown on another page, explains how to connect the parts of the simple crystal receiver. The small arrow head in contact with the tuning coil represents the slider. The arrow head shown as part of the detector represents the cat-whisker.

minal of the fixed condenser to one terminal of the crystal detector and to one of the PHONE binding posts. Run a wire from the other PHONE binding post to the crystal detector, to the slider, and from there to the GROUND binding post.

To put the set in operation, connect an antenna to the ANTENNA binding post and a ground to the GROUND binding post. Connect a pair of radio head-phones or a single 1,000-ohm radio telephone receiver to the PHONE binding posts. The antenna should be a carefully insulated horizontal wire fifty to seventy-five feet long, at least thirty feet above the earth. An indoor antenna is not usually



The round black dots represent binding posts.

effective in a steel-frame building, but in a brick or frame dwelling, an indoor antenna in the attic or top floor will often bring signals in as well as an outdoor antenna could. The ground wire should make a good electrical connection to the nearest water pipe, gas pipe, or radiator. In the country a good ground can be secured by connecting to a well pipe.

After connecting the receiver to the antenna and ground, place the head-phones on the ears and adjust the detector so that the contact point rests on a sensitive spot of the crystal. You can do this by "feeling around" with the contact on the surface of the crystal and at the same time moving the slider back and forth over the tuner until you hear signals in the phones. Or, you can use a test buzzer. To do this, you need a small buzzer, a dry cell, and a switch or push button connected in series so that closing the switch or pressing the button will put the buzzer in operation. A wire should be connected from one side of the buzzer to the ground as shown in the circuit diagram illustrating the test buzzer. The buzzer acts as a tiny transmitter and its signals can be heard in the telephone receiver. Move the contact point around on the crystal and adjust its tension or pressure against the crystal until the sound of the buzzer is loudest. When you have made this adjustment, the detector is in a sensitive condition, and, by moving the slider back and forth over the coil, you should be able to tune in a station. The position of the slider which gives the loudest signals is the proper tuning adjustment.

CHAPTER V

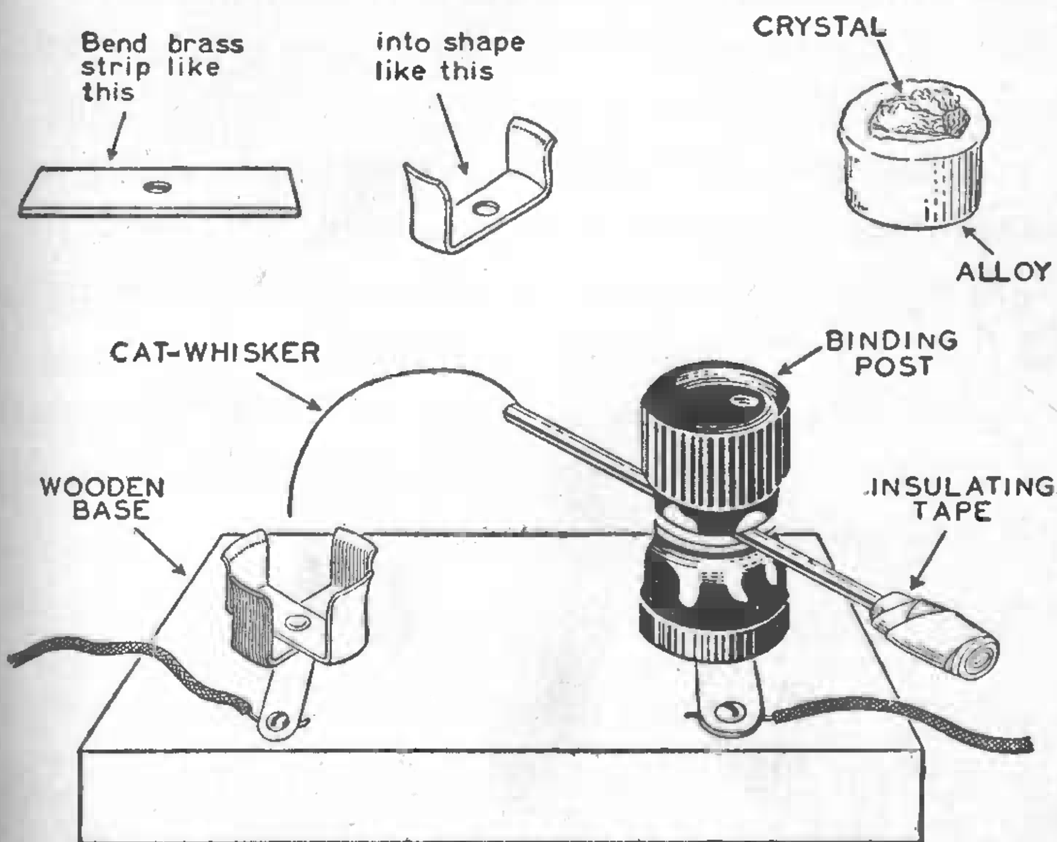
More Crystal Detectors and Crystal Receivers

HOW TO MAKE A CRYSTAL DETECTOR

THE ESSENTIALS of a crystal detector are a piece of sensitive mineral and a fine wire or spring which makes contact with the crystal and is usually called the "cat-whisker" or just plain "whisker." The crystal should be held firmly in a small cup or clamp. The suitability of any one kind of whisker varies with the kind of mineral used. The whisker should be arranged so that it can be moved over the surface of the mineral to find the most sensitive spot and so that the pressure can be varied to secure the best adjustment.

A clamp for holding the mineral can be made out of two strips of thin sheet brass or copper. One of the illustrations shows the proper size and directions for bending the strips.

The cat-whisker for a galena detector should be a piece of No. 30 B. S. gauge spring brass, phosphor bronze, or German silver wire. Copper wire makes a good contact but usually it does not have spring enough. Solder the whisker to one end of a short piece of stiff copper or brass wire which will pass through the wire hole in a binding post. Wind the opposite end of the copper wire with some Scotch tape so as to form a handle and insulate the wire



HOW TO MAKE A GALENA DETECTOR

The clamp for holding the mounted crystal is formed out of two small strips of sheet brass. The pressure of the cat-whisker against a galena crystal should be very light. The whisker should be a piece of No. 30 B. S. gauge spring brass, phosphor bronze, or German silver wire. If No. 30 wire can not be obtained, a finer wire is preferable to one which is coarser.

from the fingers when adjusting the detector. Mount the binding post with a spring-washer so that the entire post turns when the copper wire is moved from side to side. Sliding the wire back and forth and turning the post will enable the end of the cat-whisker to be brought into contact with any portion of the crystal held in the clamp. Turning the wire will vary the pressure of the whisker against the mineral. When the best adjustment has been obtained, the wire can be locked in position by tightening the knob on the binding post.

You can use a detector of this sort in building any of the receivers described in this chapter.

There are two varieties of galena which may be used as a detector, the ordinary cubical kind and the granular, so-called "steel" galena. Steel galena is the more sensitive and brings in messages from the greater distances. More details about this will be found below.

EXPERIMENTING WITH CRYSTAL DETECTORS

Although there were many different kinds of radio detectors at the time, for about ten years prior to the World War, the best was a crystal. Then vacuum tubes proved to be better, and about 1916 the vacuum tube began rapidly to replace crystal detectors.

General H. H. Dunwoody of the United States Army was the inventor of the crystal detector. In 1906 he discovered that a fragment of Carborundum would act as a detector of electric waves. Shortly afterward, another American inventor, Greenleaf W. Pickard, patented the use of silicon, zincite, chalcopyrites, bornite, and molybdenite as detectors.

There are a number of minerals which are useful as crystal detectors. Below is a partial list. If you have a mineral collection, it will be interesting to test some of the specimens to see if they will act as detectors. Not every piece of those minerals in the list will prove to be sensitive. In order to obtain a sensitive detector you may have to break up a large piece and test all the fragments.

Detector Crystals

Common Name	*Chemical Name*
Carborundum	Silicon carbide
Fused Silicon	Silicon
Iron Pyrites	Iron sulfide
Copper Pyrites	Copper sulfide
Chalcopyrites	Copper-iron sulfide
Hessite	Telluride of silver and gold
Zincite	Zinc oxide
Octahedrite	Titanium oxide
Stibnite	Antimony sulfide
Galena	Lead sulfide
Molybdenite	Molybdenum sulfide
Zirconium	Zirconium
Niccolite	Nickel arsenide
Domeykite	Copper arsenide
Anatase	Titanium dioxide
Bornite	Copper-iron sulfide
Cerusite	Lead carbonite
Chalcocite	Copper sulfide
Cuprite	Cuprous oxide
Psilomelane	Manganese manganite

The minerals in this list which are the most sensitive detectors are Carborundum, silicon, galena, and iron pyrites.

CARBORUNDUM

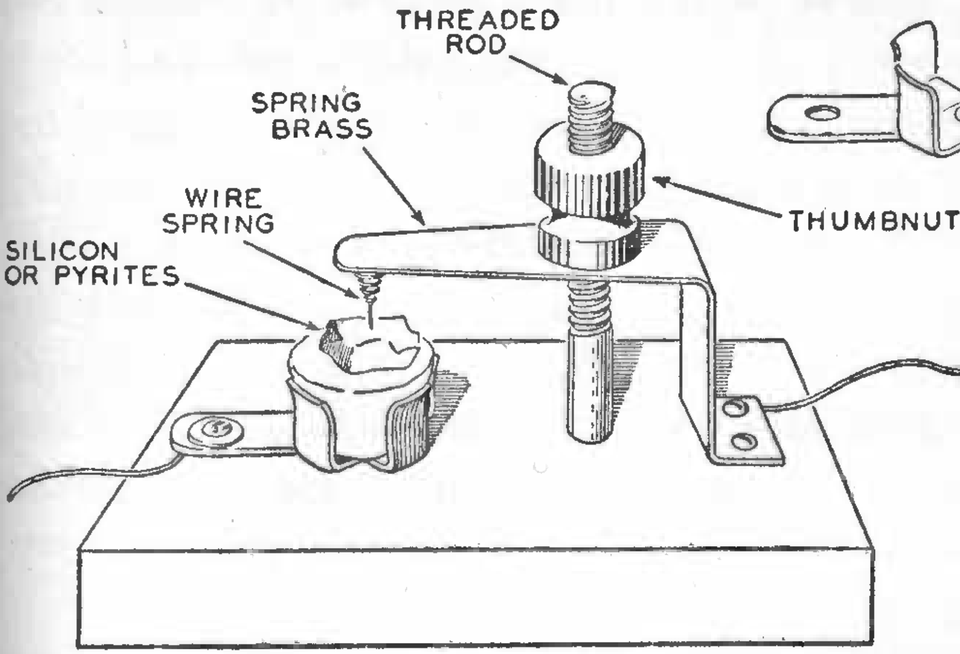
Carborundum is a product of the electric furnace, made by heating coke, sand, sawdust, and salt. The best crystals for radio are usually bluish-gray. Instead of a fine cat-whisker, use a pointed piece of stiff copper wire in contact with a sensitive spot on Carborundum.

SILICON

Fused silicon is also made in the electric furnace. It is not as sensitive as galena but produces loud signals from near-by stations and is not easily "knocked out" of adjustment. Instead of a fine cat-whisker, use a pointed piece of stiff brass or copper wire to make contact with silicon. It should bear firmly against the sensitive spot.

IRON PYRITES

Iron pyrites is the mineral known as "fool's gold." It occurs in cubical crystals of a brass-yellow color. Use a pointed brass or copper wire to make contact with a sensitive spot. Firm pressure is needed. Iron pyrites was once widely used in commercial radio stations in Europe. A pointed gold wire was used to make contact with the sen-



HOW TO MAKE A SILICON OR IRON PYRITES DETECTOR

The pressure of the cat-whisker against a crystal of silicon or iron pyrites must be heavier than the pressure against a galena crystal. The detector illustrated above is better suited to silicon and iron pyrites than the detector shown in the foregoing illustration. The cat-whisker is a short wire spring soldered to the end of a brass strip which can be raised and lowered by turning the thumbnut. The lower end of the threaded rod which carrries the thumbnut is pointed and driven into the wooden base like a nail. Turning the crystal and swinging the clamp from side to side make it possible to bring the cat-whisker against any point on the crystal.

sitive spots. If you experiment with iron pyrites, try the point of a gold stick-pin as contact.

GALENA

Galena usually forms cubical crystals with a metallic luster similar to silver. It is a soft mineral, easily split apart with the blade of a pocket-knife.

Galena is usually more sensitive than Carborundum, silicon, or iron pyrites but is more easily thrown out of adjustment. Galena crystals should be renewed often as they gradually lose their sensitivity when exposed to air. Contact with a sensitive spot on the crystal should be made with a fine wire and very light pressure.

"STEEL" GALENA

This mineral is the most sensitive of all. It is a variety of galena which contains a small percentage of silver and is often called argentiferous or granular galena. It resembles a piece of broken steel in appearance.

Steel galena is alive with sensitive spots. A fine German silver wire pressing lightly against a sensitive spot makes the best contact. As is the case with ordinary galena, heat reduces its sensitiveness.

HOW TO SELECT AND MOUNT GALENA CRYSTALS

Ordinary galena is not sensitive over its entire surface. In order to find some suitable pieces it may be necessary to break up a large piece and "search" or test the fragments for sensitive spots. Test each piece by using it as a detector and listening for signals. When a sensitive piece has been found, mark the best spot on it with white chalk. Split away most of the non-sensitive area with a small chisel or knife blade.

The best results are secured from a piece of galena when it is embedded, sensitive side up, in a small slug of low-temperature alloy such as one of the alloys which will melt in boiling water. Solder should not be used for this purpose. Its melting point is too high, and to imbed a crystal in it would subject the crystal to too much heat.

Wood's metal is the best known of the low-temperature alloys and can be purchased from dealers in chemical supplies. A low-temperature alloy which will melt in boiling water may be prepared by the experimenter from the formula which follows. The lead should be melted first, the bismuth added, and then the tin. The formula is given in parts so that you can use grams, ounces, or any unit you care to in weighing the ingredients. A copper cent makes a convenient unit of measure in weighing out ingredients for a small quantity of alloy on a home-made balance. Use enough bismuth to balance eight pennies, enough lead to balance five pennies, and enough tin to balance three pennies.

LOW TEMPERATURE ALLOY

(*Melting point 201° F.*)

Bismuth	8 parts by weight
Lead	5 parts by weight
Tin	3 parts by weight

Avoid touching sensitive crystals with the fingers, as a slight bit of oil and dirt, even if it can not be seen, reduces the sensitivity. Instead of the fingers, use a pair of steel forceps to handle crystals.

A small metal ferrule (about the diameter of a dime) may be used as a mold for casting the slug. If the ferrule has a hole in the bottom, plug it with a tight fitting cardboard disk. Pour the molten alloy into the mold, and before it has a chance to cool and become solid, press the selected galena into the molten metal with a pair of forceps. The surface with the most sensitive spot should be uppermost. When the alloy has cooled it will shrink and can be easily removed from the mold.

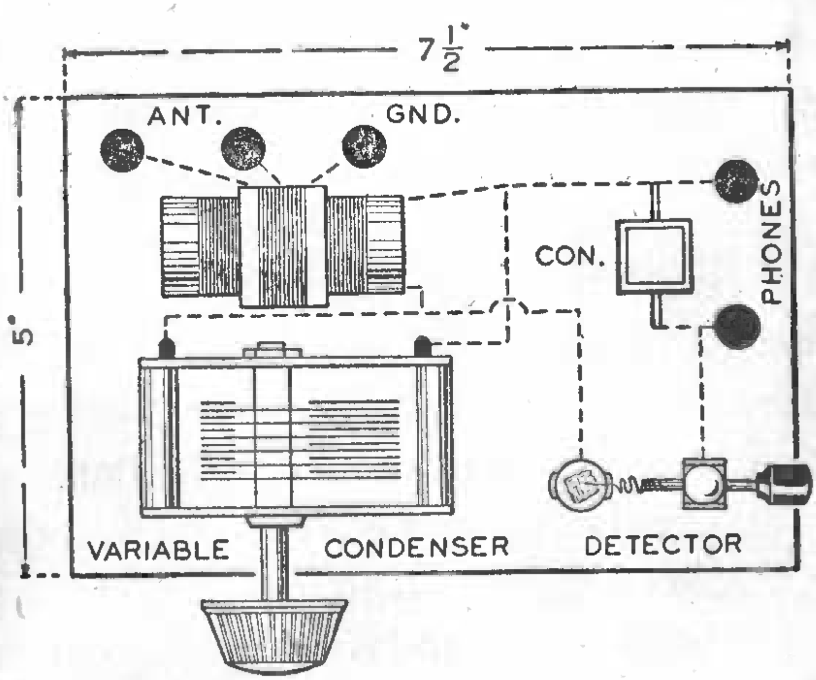
HOW TO BUILD A SELECTIVE CRYSTAL SET

A receiving set composed of a crystal detector, fixed condenser, tuning coil, and telephone receiver does not have much *selectivity*. This means that it can not be tuned sharply so that its circuits respond efficiently to a desired wave-length and only one station is heard at a time. In order to be selective, a receiver must employ a radio-frequency transformer or *coupler* and be tuned by means of a variable condenser. A coupler consists of two windings, a primary and a secondary. The windings are not electrically connected. They are magnetically connected, however, and a current flowing through the primary will cause a current to flow in the secondary by the process called induction.

Induction is a very important process in radio circuits. All modern radio receivers use a transformer to couple the antenna and ground to the receiver. Transformers are used to couple the antenna to the detector, the detector to the amplifier, and the various stages or steps of amplifier to each other.

If you build a crystal receiver employing a transformer

PLAN OF SELECTIVE CRYSTAL SET



The dotted lines represent the wires which connect the various parts. If the antenna connected to this receiver is 50 feet long or less it should be connected to the left hand ANT. post. If it is from 50–75 feet long, connect it to the right hand ANT. post so that only twelve turns of the primary coil are in circuit.

or coupler and tuned with a variable condenser, you will find that it is much more efficient and more selective than the crystal receiver employing a simple tuning coil.

You will need the following parts:

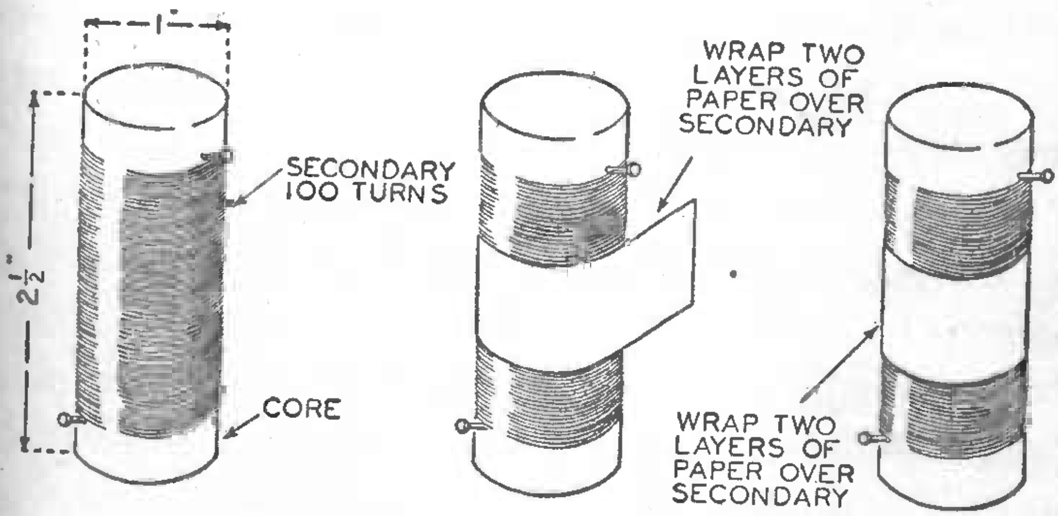
1 Wooden base 7" x 5" x ¾"
1 Variable condenser, 100 Mmfd. with knob

1 Mica fixed condenser, .004 Mfd.
1 Crystal detector
40 feet enameled magnet wire
5 Binding posts
1 1,000-ohm receiver or radio head-set

First, make a smooth wooden base 7 inches long, 4¾ inches wide, and ¾ of an inch thick. The thickness is not important; neither is the variety of the wood. A smooth piece of white pine cut to dimensions and given a coat of shellac will serve well.

When the base has been made, build the coupler. This consists of two windings, a secondary composed of one hundred turns of enameled magnet wire and a primary composed of twenty-four turns. The secondary is wound smoothly and evenly in a single layer on a round wooden core or a cardboard tube one inch in diameter. To prevent shrinking and loosening of the winding, the core must be dried in an oven and shellacked before the wire is put in place. The size of the wire is not important. No. 30 B. S. gauge is a suitable size. Anything smaller than No. 36 will be unsatisfactory. The core should be 2½ inches long, and the winding should be placed so that it begins and ends an equal distance from each end. The terminals of the coil can be anchored by soldering to two brass pins driven into the wooden core. If a cardboard tube is used as core, slip the ends of the wires through holes drilled into the tube. The primary is wound over the secondary but is separated from the latter by two or three layers of paper. The wire should be the same size as that used for the secondary. It consists of twenty-four turns of wire "tapped" in the center. "Tapped" in the center means that when twelve turns have been wound on, the wire is

Winding the Coupler



The coupler consists of two windings, a secondary of 100 turns and a primary of 24 turns. The primary is wound over the secondary but is separated from it by two layers of paper. The primary is not shown in the sketches above. See text for further details.

twisted as shown in the sketch. Then twelve more turns are wound on. The terminals of the primary may be anchored with a strip of adhesive tape. The enamel insulation should be scraped off the "tap" in the center of the coil and a piece of push-back wire four inches long soldered to it. The primary will then have three terminals, one in the center and one at each end. We will see why later.

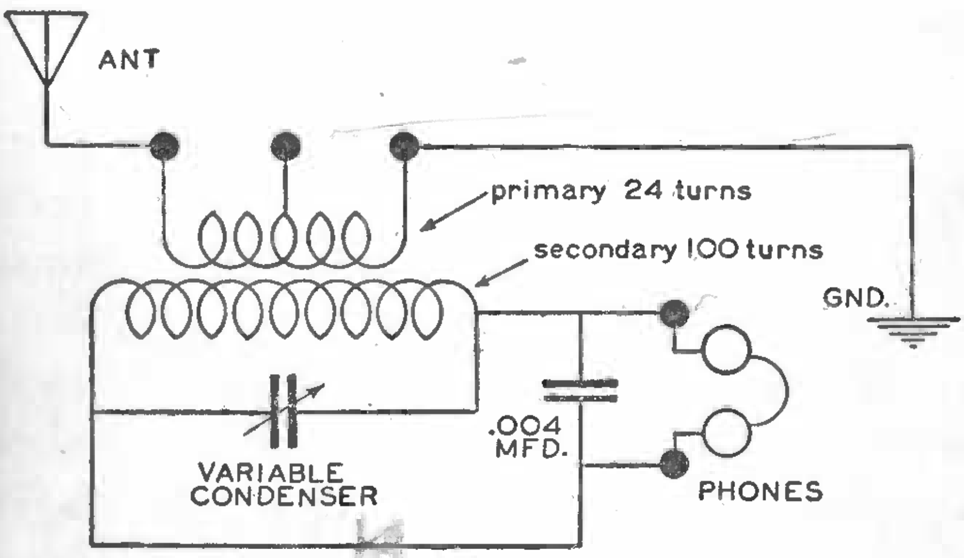
The plan of the completed set shows the location of the finished parts on the base. The detector is placed to the right of the variable condenser. The coupler is back of the condenser. The fixed condenser is in back of the detector. The dimensions of the illustration are exactly one-third those of the finished receiver.

Any good crystal detector may be used. When all the parts are in place, the set is ready to wire. The dotted lines in the plan represent the wires which connect the various parts. By studying the plan and the schematic wiring diagram you should be able to wire the receiver without any difficulty. Use push-back wire and solder all connections.

Connect one of the end terminals of the primary winding to the GROUND binding post. Connect the other end terminal to the first ANTENNA binding post. The center tap should be connected to the second ANTENNA post. The terminals of the secondary should be connected to the terminals of the variable condenser. One terminal of the detector is then connected to one terminal of the variable condenser, and the other terminal of the variable condenser is then connected to one of the PHONE posts. The other PHONE post is connected to the detector. The fixed condenser is connected directly across the PHONE binding posts.

The receiver is then ready to operate. Connect the ground binding post to the nearest water pipe or radiator or other suitable ground. The antenna should be from fifty to seventy-five feet long, properly insulated and at least thirty feet above the earth. If the antenna is short (fifty feet or less) it should be connected to ANTENNA

SCHEMATIC CIRCUIT FOR
SELECTIVE CRYSTAL SET



This type of receiver, in which the antenna is coupled to the detector by a transformer, is much more selective than the simple tuning coil set. The base and the transformer or coupler are home-made. The other parts, unless you want to make your own detector, should be purchased at a radio shop.

post, 1, so that all twenty-four turns in the primary coil are included in the circuit. In the case of a longer antenna, connect it to ANTENNA post, 2, so that only twelve turns of the primary coil are in the circuit.

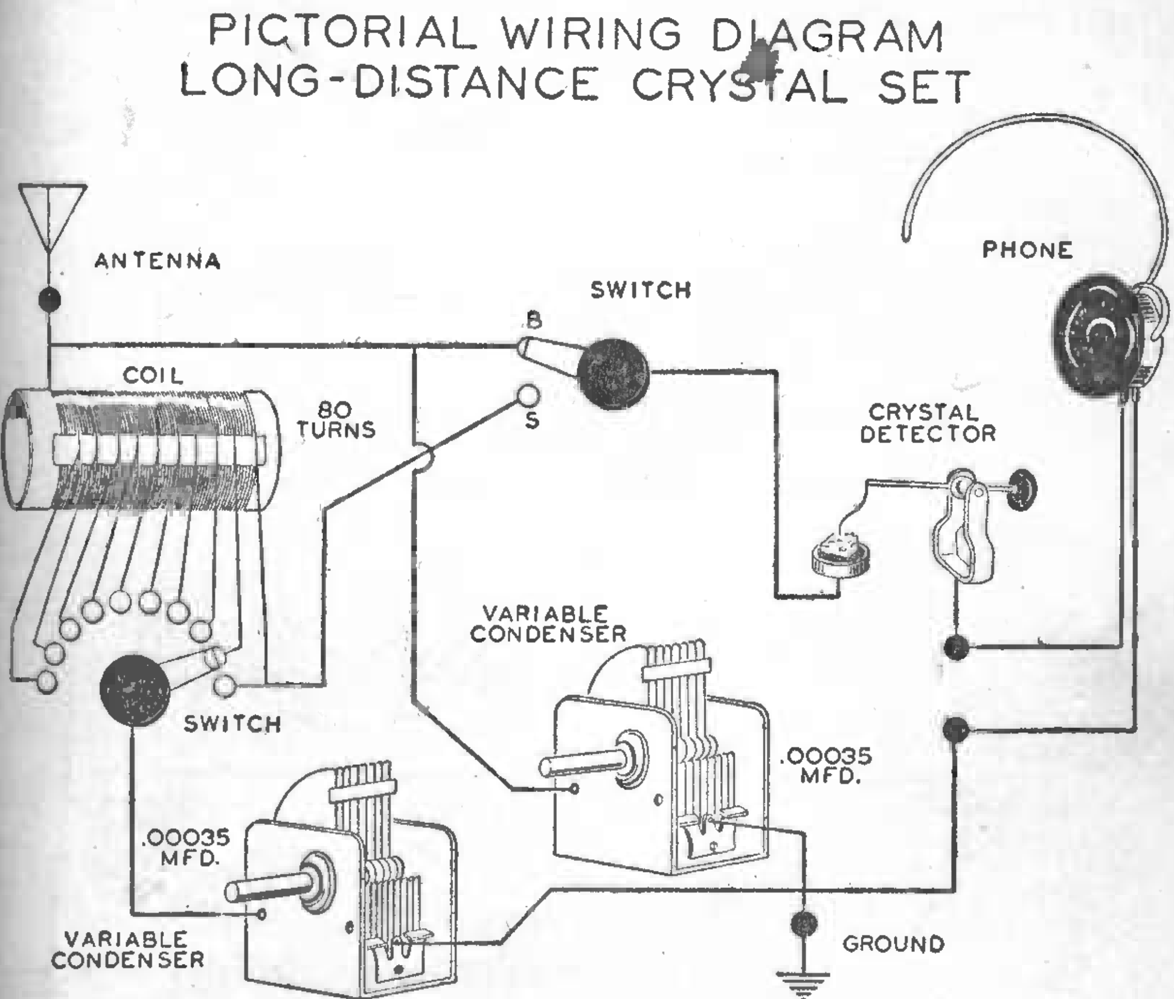
Connect a pair of radio head-phones or a single 1,000-ohm receiver to the PHONE binding posts. Adjust the detector by using a test buzzer in the manner already described. With your phones on your ears, turn the variable condenser very slowly. If you are within receiving range of a broadcasting station you will hear it. Adjust the variable condenser until the signals are loudest. Then readjust the detector. You may be able to improve the adjustment secured with the test buzzer. Once the most sensitive spot on the crystal has been found and the pressure of the contact properly adjusted, be careful not to jar the receiver.

HOW TO BUILD A LONG DISTANCE RECEIVER WITH CRYSTAL DETECTOR

This receiver is more selective and efficient than either of the crystal detector sets which have already been described. It consists of a crystal detector using "steel" galena, a pair of radio head-phones, two variable condensers, two switches, and a "tapped" inductance or coil. With a sensitive "steel" galena crystal it is possible to pick up stations several hundred miles away. When enclosed in a cabinet, it is a handy receiver to take along on a camping trip. It is compact and light, there are no batteries. Just run a 100-foot wire to a tree as an antenna, drive a pipe into the ground as an earth connection, connect the receiver—and it is ready to use.

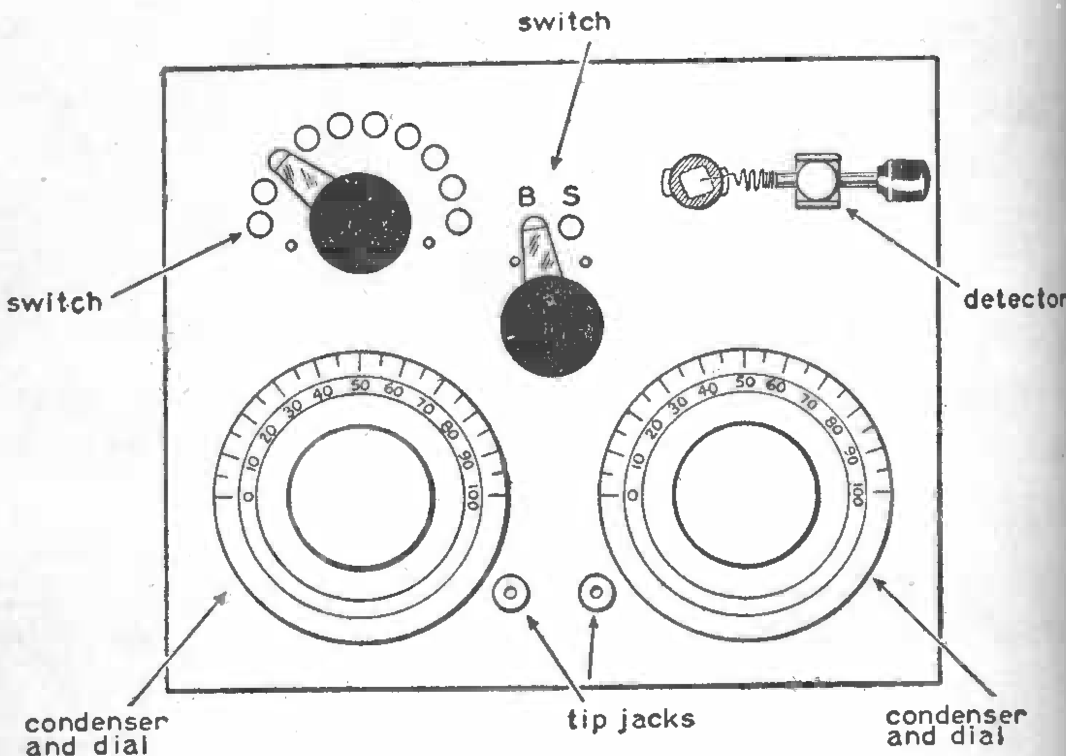
A "tapped" coil is one which has wires or "taps" leading from several points on the coil to a switch, so that part or all of the coil can be cut in or out of the circuit by adjusting the switch.

The set is tuned by the two variable condensers and the switch connected to the tapped coil. There are two



Turning the two-point switch to B sets the receiver to tune broadly. Turning the switch to S makes the receiver selective. Adjusting the 10-point switch and the two variable condensers tunes the receiver to incoming signals. To pick up a station, turn the 2-point switch to B and set the 10-point switch on the fourth or fifth contact. Turn the condensers very slowly. When you hear signals, readjust the 10-point switch, the condensers, and the detector until the sounds are loudest.

switches. One of them, the two-point switch, broadens or sharpens the selectivity of the set. Throwing the two-point switch to contact B makes the tuning broad. It is easier to pick up stations in this position. Throwing the switch to S makes the tuning very sharp or selective. Then near-by unwanted stations will not interfere with signals



FRONT VIEW OF THE LONG-DISTANCE RECEIVER WITH CRYSTAL DETECTOR

The tuning coil and the two variable tuning condensers are mounted on the back of the panel. The condenser shafts project through far enough so that they can be fitted with a knob and dial.

coming from a greater distance which you may want to hear, but the receiver will be harder to tune.

In the country you can use a single wire antenna 100 to 150 feet long. Make it as high as possible. The set will tune in all the broadcast wave-lengths and go as low as twenty meters.

The ten-point switch connected to the coil or inductance has a marked effect in changing the wave-length or frequency to which the set is tuned. It cuts a varying number of turns of the coil—from five to eighty—in or out of the circuit. When five turns are cut in by moving the switch lever to the first contact, the set will receive the shortest wave-lengths or the highest frequencies. When all the turns (eighty) are switched in by moving the lever to the last contact, the set will receive the longest wave-lengths or the lowest frequencies. The final adjustment in each case is done by the variable condensers.

In order to build this receiver, the following parts are required:

1 Plywood or composition panel 8″ x 6½″ x ¼″
1 Wood base 8″ x 3½″ x ¾″
2 .0004 variable condensers
2 3-inch dials and knobs
2 Switch levers with knobs
12 Switch contact points
1 2-inch dia. tube 4 inches long
52 ft. No. 22 B. & S. gauge double-cotton magnet wire
2 Binding posts
1 Crystal detector
1 Sensitive "steel galena" crystal
2 Tip jacks or binding posts
Hook-up wire, screws, etc.

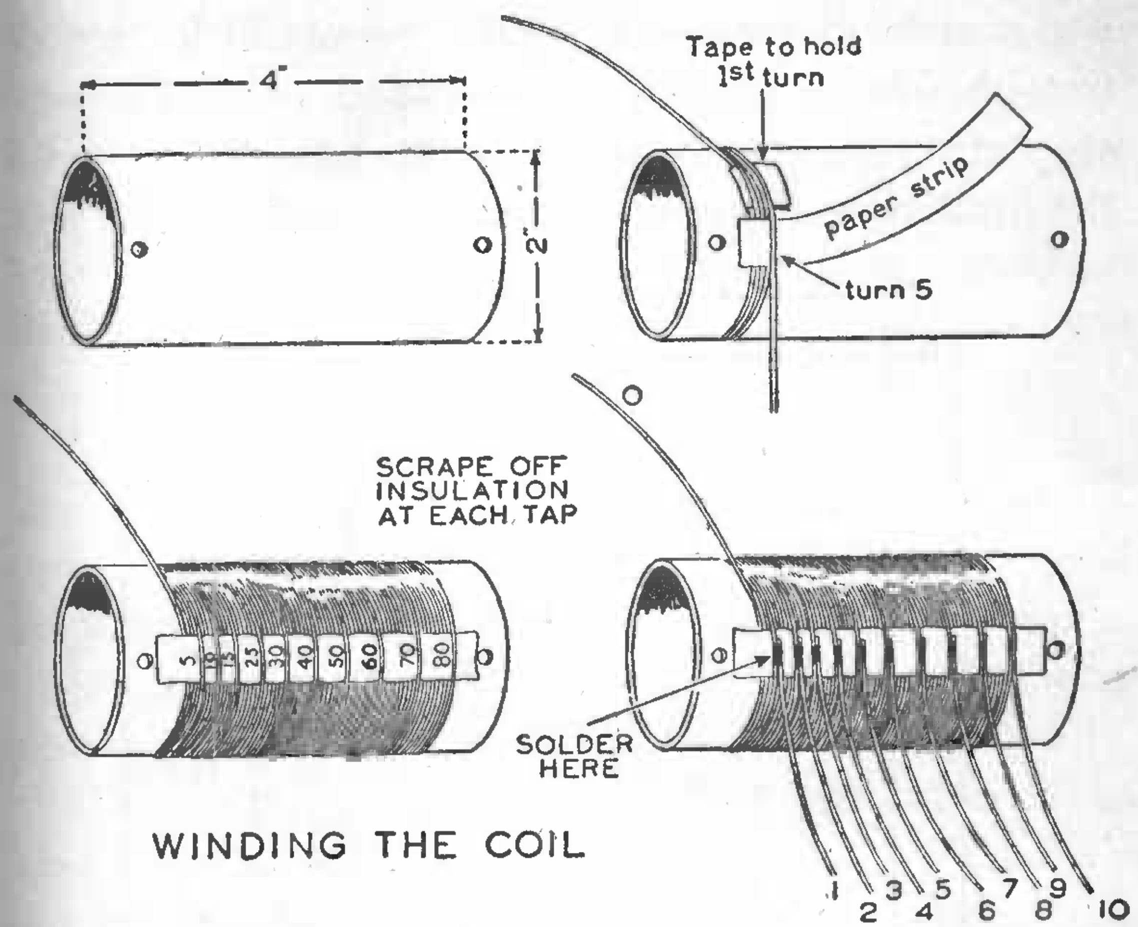
The coil consists of eighty turns of No. 22 double-cotton covered magnet wire wound in a single layer around a tube two inches in diameter and four inches long. A cardboard tube will be satisfactory if it is first dried in a warm oven (not hot) with the oven door *open* and then painted inside and out with shellac or varnish. A Bakelite tube is more desirable. Several firms which handle a complete line of supplies for radio experimenters and servicemen list Bakelite tubing in their catalogues and will furnish a piece two inches in diameter and four inches long for twenty cents.

About fifty-two feet of wire are required for the coil. Buy a ¼-pound spool and you will have plenty. There are about 464 feet of No. 22 double-cotton covered in one pound of the wire.

Start the winding about half an inch back from one end of the tube. Leave about eight inches of wire free for a terminal. You can anchor or fasten the terminal and prevent it from unwinding by making a loop of adhesive tape around the wire. Secure the ends of the loop by winding the next few turns of wire over them.

The last turn (eightieth) can also be held in place and the coil prevented from unwinding by a loop of adhesive tape bound to the coil with a strip of Scotch tape. Here, also, leave about eight inches of free wire as a terminal.

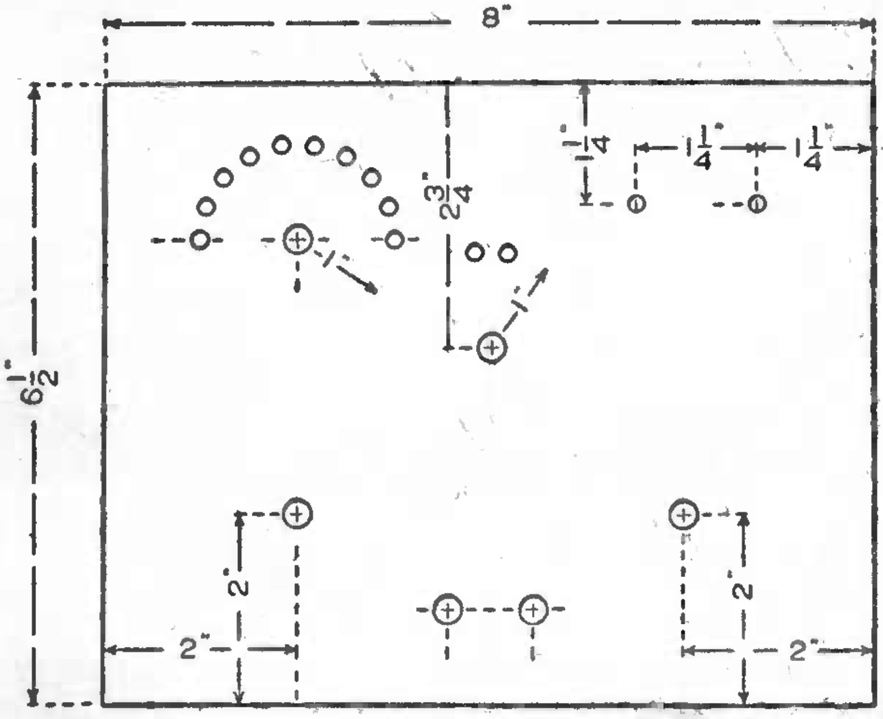
The coil is tapped at the fifth, tenth, fifteenth, twenty-fifth, thirtieth, fortieth, fiftieth, sixtieth, seventieth and eightieth turns. To do this, fold a strip of thick wrapping paper one inch wide and four inches long down the mid-



This sketch shows how the coil is wound and the taps are made. The numbers on the coil at the lower left show how many turns there are between taps. The coil is tapped at the fifth, tenth, fifteenth, twenty-fifth, thirtieth, fortieth, fiftieth, sixtieth, seventieth, and eighieth turns. A paper strip raises these turns up for making the taps. Solder a piece of push-back wire four or five inches long to each tap.

dle so as to form a double thick strip four inches long and half an inch wide.

Wind four turns of wire around the tube and slip the double strip of paper under the fifth turn. Fold the strip back out of the way and wind on four more turns. Slip the strip under the tenth turn. Continue winding, slipping the paper strip under the fifteenth, twenty-fifth, thirtieth, fortieth, fiftieth, sixtieth and seventieth turns. The paper strip raises these turns up for making the "taps." Scrape the insulation off the wire of each tapped turn for a dis-

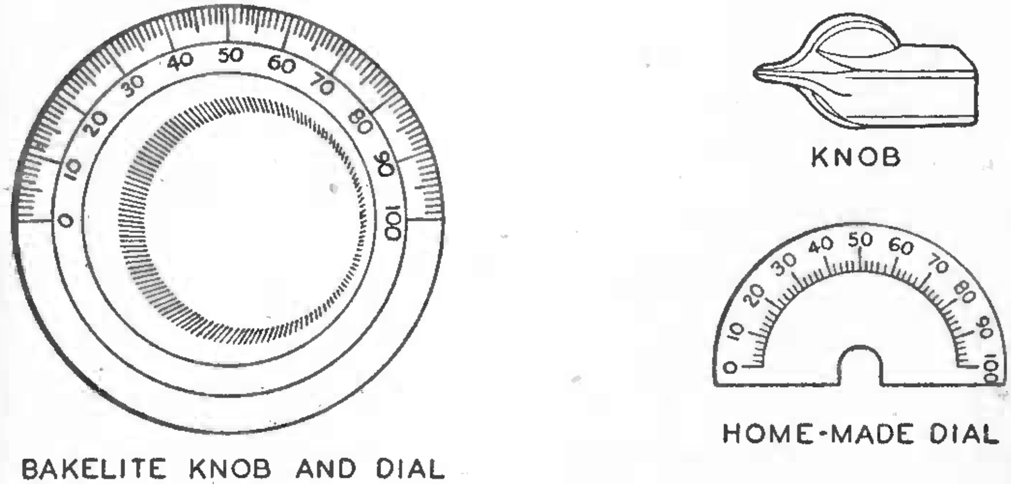


FRONT VIEW OF PANEL FOR THE LONG-DISTANCE CRYSTAL RECEIVER

The locations of the various holes for the condensers, detectors, switches, jacks and coils are shown. Mark these on a piece of ¼" dry plywood 8" x 6½" and drill them.

tance of about a quarter-inch where the paper passes under it. Solder a piece of push-back wire four or five inches long to each tap.

A piece of dry plywood ¼" thick which has been shellacked or varnished makes a good panel, but a piece of sheet Bakelite is better. One of the illustrations shows a ront view or "lay-out" of the panel. The locations of the arious holes for the condensers, detector, switches, jacks, nd coils are shown. Mark these on the panel and drill hem. The illustration is exactly one-half the size of the nished panel. If you measure any of the dimensions of



CONDENSER CONTROLS

The adjustment of the tuning condenser on a crystal receiver is not close nough to warrant a vernier control. The shaft may be provided with a 3-inch nolded knob and dial or with a knob alone. In the latter case you can make a aper dial like that shown in the lower right-hand corner of the sketch above nd fasten it to the panel with shellac or varnish.

he drawing, double them, and they will be the correct ize to use in marking or laying out the panel.

When the panel has been cut to size and drilled, fasten t to the front edge of the base. Then mount the two variable condensers on the back of the panel. The condenser hafts should project through far enough so that they can e fitted with a knob and dial.

A molded Bakelite knob and dial, both of which turn with the condenser shaft, may be used, or a bar knob and pointer moving against a dial attached to the panel. With the aid of a protractor, you can make a dial on drawing paper (use drawing ink) and fasten it to the panel with shellac or varnish.

Bend the tip of one of the movable (rotor) plates on the condenser mounted under the switch (left side of panel looking from front) so that it comes into contact with the fixed plates (stator) and short circuits the condenser when closed.

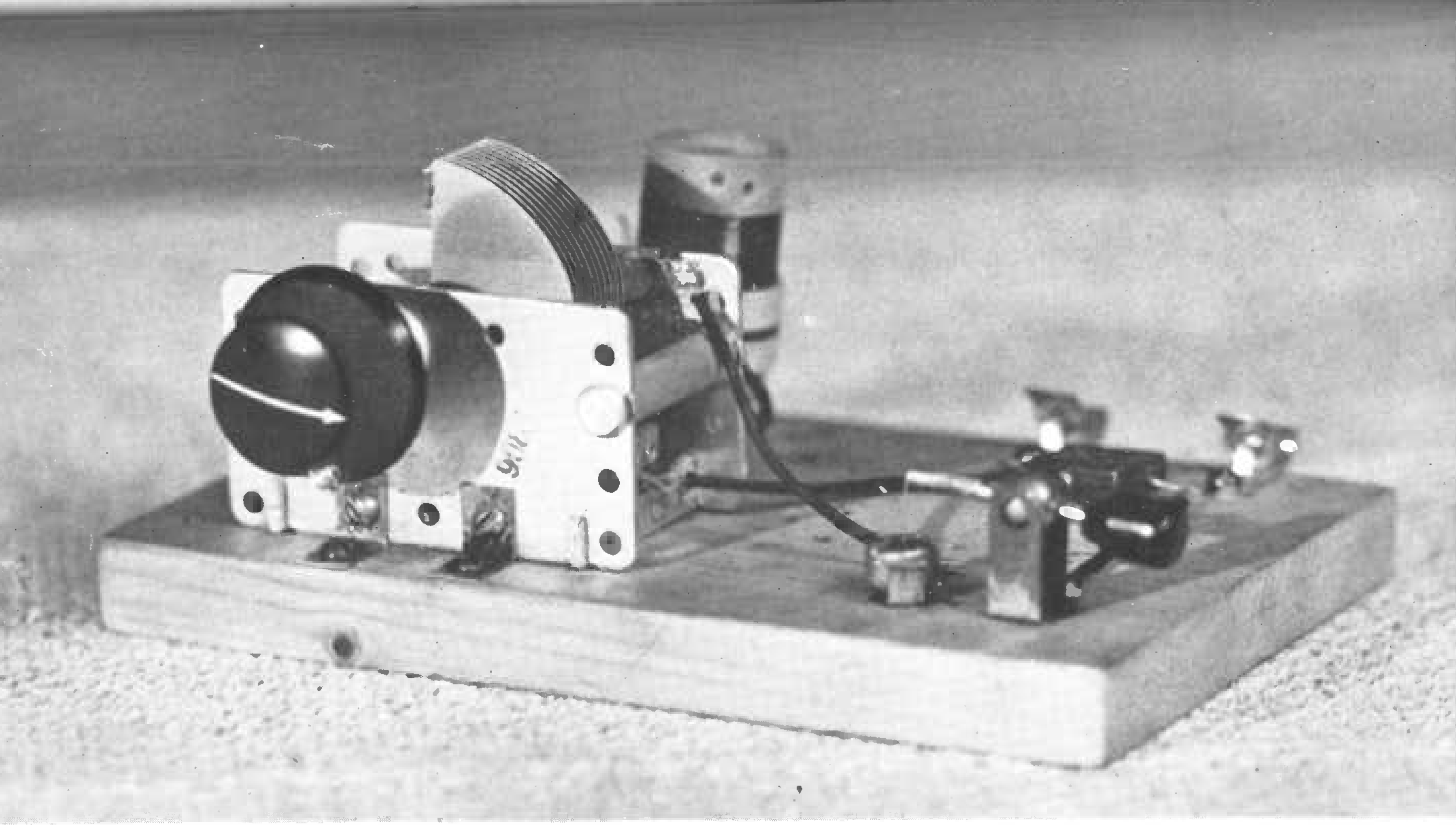
Factory built switches will prove more satisfactory than home-made ones.

The ANTENNA and GROUND binding posts are mounted on the base. The crystal detector is mounted on the front of the panel at the upper right-hand corner.

The coil is mounted on the back of the panel in back of the switch. It is the last one of the parts to be put in place. It will be easier to wire the set if as much of the wiring as is possible is put in place before the coil is mounted. The coil is fastened to the panel by two 8-32 machine screws and nuts. Use a spacer or a number of washers between the coil and the panel.

All connections should be soldered. Use push-back wire and make all wires as short as possible. Consult both the schematic and the pictorial diagrams and make certain to get everything connected correctly.

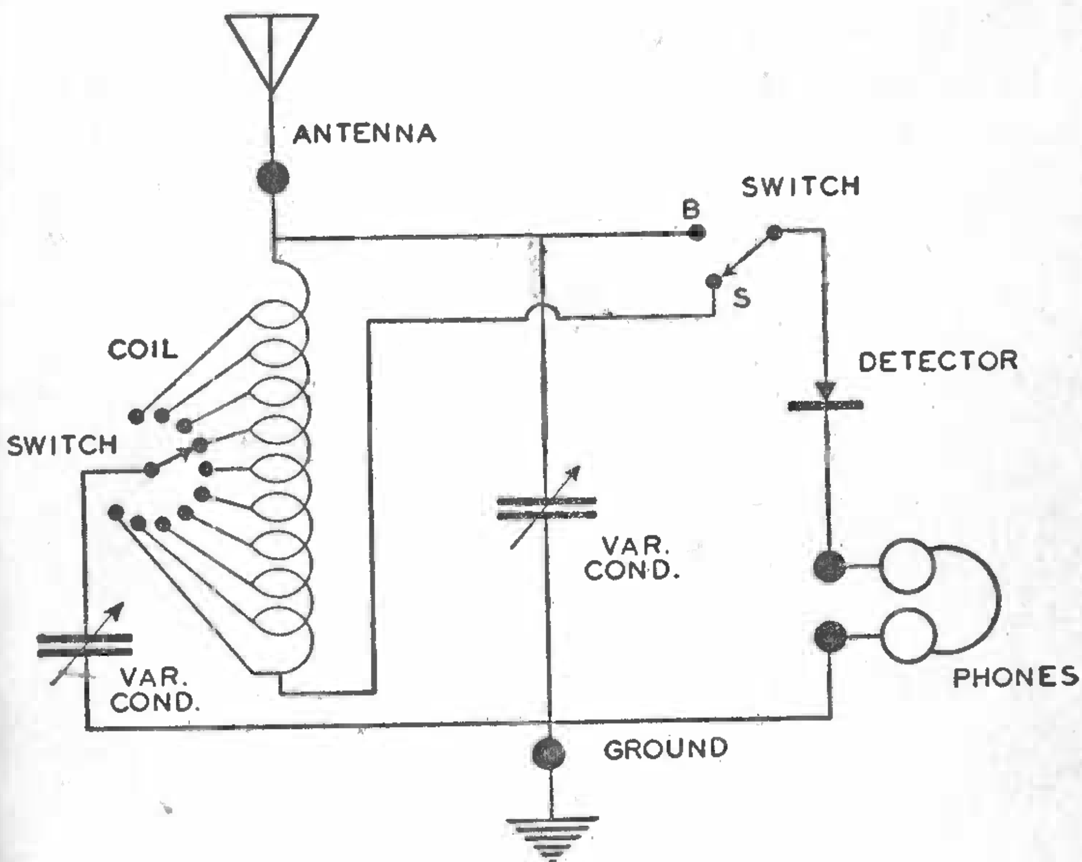
When the wiring is completed and checked, the re-



The selective crystal set (page 84) is tuned with a variable condenser and a coupler.

With this one-tube receiver you can tune in broadcasting and amateur stations, short-wave police ceiver is ready to operate. Connect the antenna and ground to their proper binding posts. If possible, the an-

SCHEMATIC WIRING DIAGRAM
LONG-DISTANCE CRYSTAL SET



The large black dots represent binding posts. The small black dots are switch contact points.

tenna should be 100 to 150 feet long and as high as possible. Turn the switch to B so as to set the receiver to tune broadly. Slip the terminals of a telephone receiver or headset into the phone tip jacks. Adjust the cat-whisker on the surface of the steel galena. The detector will not require careful adjustment for near-by or local stations, as a good piece of steel galena is usually sensitive all over. Set the ten-point switch on the fourth or fifth contact and adjust both condensers. Turn the condensers very slowly and listen intently for signals. When you hear a signal, readjust the switch and see if you can bring it in louder.

Long-distance signals can usually be heard only at night and only if the detector is carefully adjusted.

CHAPTER VI

Building Your First Receiver with a Vacuum Tube Detector

A RECEIVER with a vacuum tube detector is not as simple as a receiver with a crystal detector. But if by first building a crystal detector set, you have become somewhat familiar with basic radio parts and their functions, with the meaning of the various radio symbols, and with wiring or connecting the parts, you will not find it difficult to construct the one-tube battery-operated receiver described in this chapter.

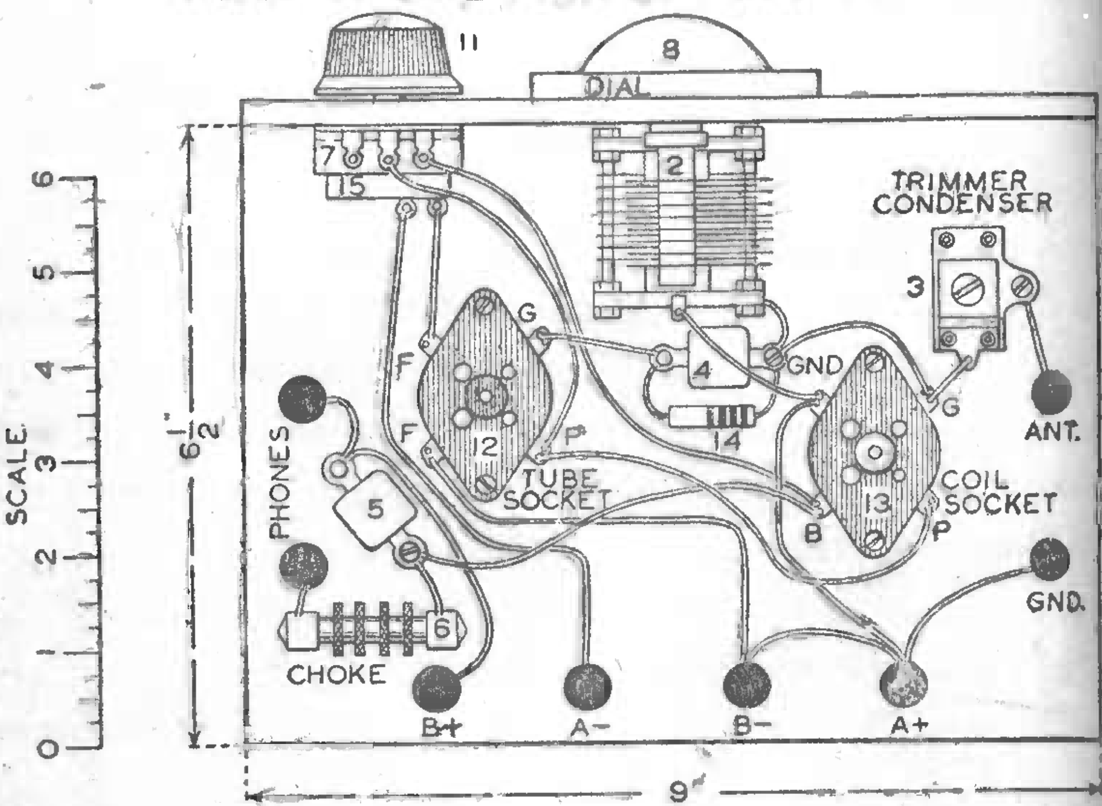
There are three types of radio receivers in common use employing vacuum tubes.

Most commercially built sets are *superheterodynes.* This type is the most sensitive, but it does not give the most faithful reproduction of signals. Since a superheterodyne requires several vacuum tubes, it is not well suited to the purposes of the beginner at radio building.

Next to the superheterodyne, *tuned radio frequency* receivers are most common. They are not quite as selective but give better "fidelity," that is, reproduce signals more faithfully. Since this type also requires more than one tube, it is not simple enough to be suitable for a beginner.

The *regenerative* receiver is the third principal type. It

PLAN OF ONE-TUBE BATTERY SET



Sometimes failure of a receiver of this type to operate when it is tested the first time is due to the tickler-coil winding being reversed. If the wiring, batteries, tube and phones have been checked and found in order, reverse the wires attached to the terminals on the coil socket (13) marked B and P in the plan. Do not make this change until it is certain that the failure of the receiver to operate is not due to any other cause.

is sensitive and selective enough for ordinary purposes, is the easiest to wire, and, since it may be constructed in a one-tube model, is most suitable for the beginner.

A battery-operated vacuum tube receiver is simpler than one operated by current from the house-lighting circuit. Therefore, even though you have 110-volt current in your home, build a battery-operated set first. Then you can progress to receivers built for 110 volts and to building more elaborate radio equipment.

Just one more bit of advice. If, in the beginning, vacuum tube circuits look complicated and mysterious, think how you learned to do the many different things which you can do. It was by trying, was it not? Assembling a receiver, making the connections and checking them can be done quickly and easily after a little practice. There are several hundred amateur radio builders in the United States. Some of them build very elaborate and complicated transmitters and receivers, equal in workmanship to the best professional jobs. These "hams" first began by doing simple work and gradually advanced to more pretentious things. This is by far the best method. It is worth following.

A ONE-TUBE REGENERATIVE RECEIVER

This receiver can be built quickly and easily. The parts are inexpensive. The total cost including tubes and batteries but not including telephone receivers is approximately seven dollars. It will prove much more satisfactory, more sensitive, and more selective than a receiver employing a crystal detector.

A one-tube receiver will not develop sufficient output to operate a loud-speaker and must be used with head-phones. There is an advantage in this. You can use it alongside your bed or when others are asleep, and it will not annoy any one. Since the batteries are small and light, the set is portable. You can take it along on a camping trip.

With this receiver and a kit of plug-in coils for both short waves and the broadcast band you can tune in the amateur stations in the United States and other countries; short-wave police calls; ships at sea; airplane calls; commercial radiophone messages; short-wave stations which transmit from Canada, Europe, Mexico, Asia, Africa, Australia, and South America; and broadcast stations in the United States, Mexico, and Canada.

The following parts and materials are required for building a one-tube regenerative receiver:

1 No. 30 Vacuum tube
1 Plywood panel 8″ x 5½″ x ¼″
1 Wood base 8″ x 6½″ x ¾″
1 Set of 4-prong plug-in coils for short-wave and broadcast band (1)
1 .00014 Mfd. variable condenser (2)
1 3–30 Mmfd. trimmer condenser (3)
1 .0001 Mica fixed condenser (4)
1 .00025 Mica fixed condenser (5)
1 2½-Millihenry radio-frequency choke (6)
1 1-Megohm (tapered) volume control and switch with knob (7 and 15)
1 Vernier dial (8)

8 Binding posts (9)
2 4-prong sockets (12 and 13)
1 2-Megohm ½-watt resistor
1 1½-volt dry cell
1 22½-volt "B" battery
1 Radio head-set
Screws, hook-up wire, etc.

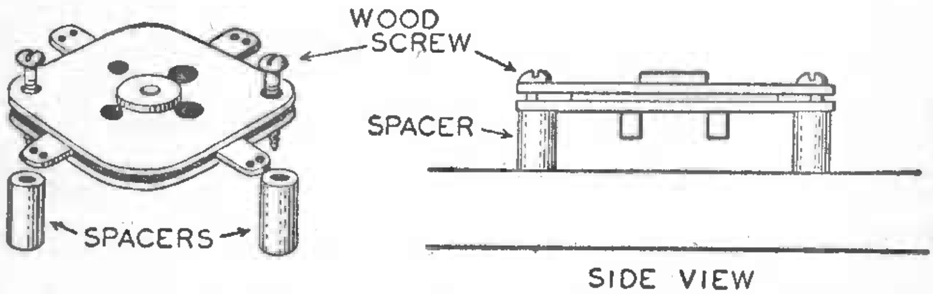
The numbers in parenthesis identify the parts in the plan and circuit diagrams.

ASSEMBLING THE RECEIVER

The first step toward assembling the receiver is to make the base and panel. A piece of white pine 8″ x 6½″ x ¾″ makes a good base. The panel should be a piece of ¼ plywood 8″ x 5½″. Both the base and the panel should be thoroughly dry and shellacked or varnished. The panel is fastened to the front edge of the base by small screws or wire nails.

The variable condenser (2) and the volume control (7) and switch (15) are mounted on the back of the panel. The knob (11) which turns the volume control and switch, and the vernier condenser control (8) are mounted on the front of the panel. If the shaft on either the control and switch or the condenser is too long—that is, if it projects through the panel too far—cut it to proper length with a hack-saw. Although the device itself (15) is a volume control, it is used in this receiver to control an action of the detector called *regeneration.* Hereafter, we will call it the regeneration control.

Mount the sockets (12 and 13), trimmer condenser (3), binding posts, choke (6), condensers (4 and 5), and resistor (14) on the base as shown in the plan. Use brass screws to fasten these parts in place. You can determine the exact locations by measuring the distances on the scale shown at the left of the plan. If base mounting sockets are



HOW TO MOUNT A WAFER SOCKET ON A WOODEN BASE

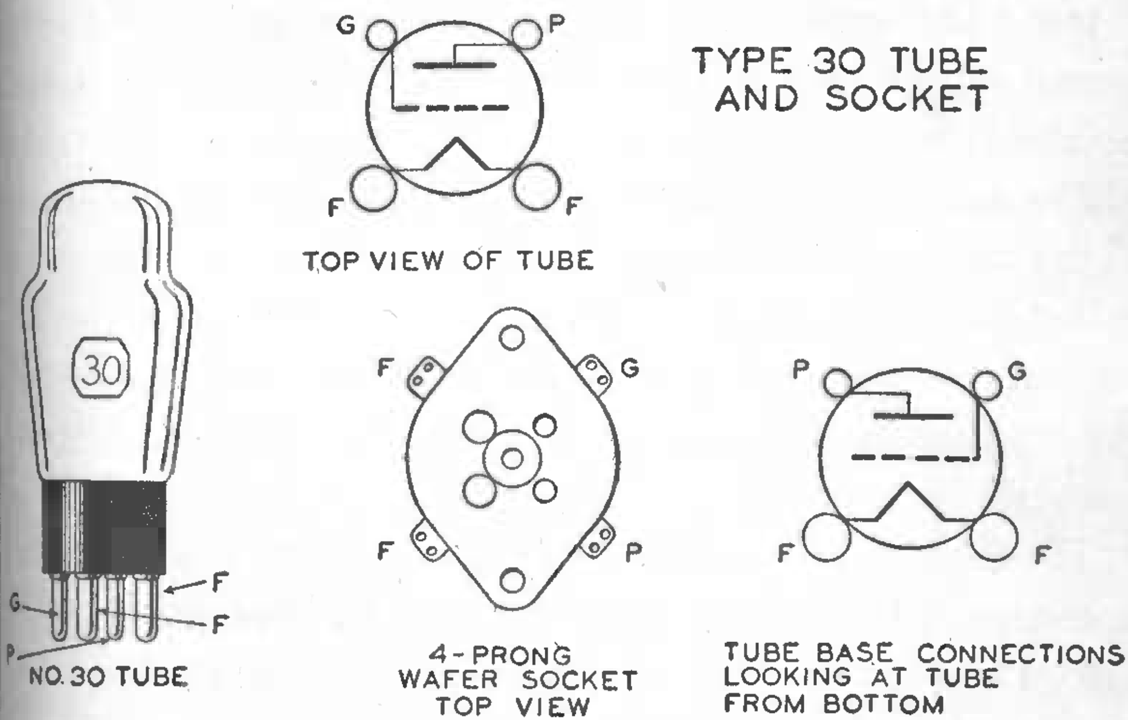
The prongs on a tube can not be properly inserted in a wafer socket unless the socket is raised above the base slightly. To raise a socket, slip a ½-inch brass spacer over the fastening screws, between the socket and the base. Spacers can be obtained from the dealer who supplies the socket.

used, they can be mounted directly on the base. If wafer sockets are used, they must be raised from the base by ½-inch spacers. This will provide room for the pins when a tube or coil is inserted. This method of mounting a wafer socket is illustrated in one of the drawings.

Notice that in each socket two of the holes through which contact pins pass are larger than the other two. Make certain that the sockets are mounted with these holes in the position shown on the plan.

WIRING THE RECEIVER

When all parts have been fastened in place on the base and panel, the receiver is ready to be wired. Consult the



TUBE CONNECTIONS

A type 30 radio tube has four prongs. Two of them (connected to the filament) are larger than the others. The difference in the size of the prongs serves to locate the tube when it is placed in the socket so that the prongs make connection with the proper socket terminals. The letters FF, G, and P in the sketch above identify the prongs connected respectively to the filament, grid, and plate, and the corresponding terminals on the socket. Notice how the G and P terminals reverse their position depending upon whether you look at the tube or socket from the top or bottom.

plan, the schematic diagram, and the pictorial diagram. Use push-back wire and solder all connections. Use rosin-core solder. As each wire is soldered in place, make a small check mark alongside the corresponding wire on the plan. Use a soft pencil, mark lightly, and you can erase it later without damage to the book. In this way you can check each connection and be certain that none are omitted.

Here are some facts and explanations regarding the circuit which may help in wiring and checking the connections:

The antenna binding post is connected to one terminal of the trimmer condenser (3). The trimmer condenser is called the *antenna condenser.* It is connected to the G terminal of the grid coil, to the variable condenser (2) stator, and to the resistor and .00014 Mfd. fixed condenser.

The 2-megohm resistor (14) is called the *grid leak.* It is connected directly across the terminals of the .00014 Mfd. mica condenser (4) called the *grid condenser.*

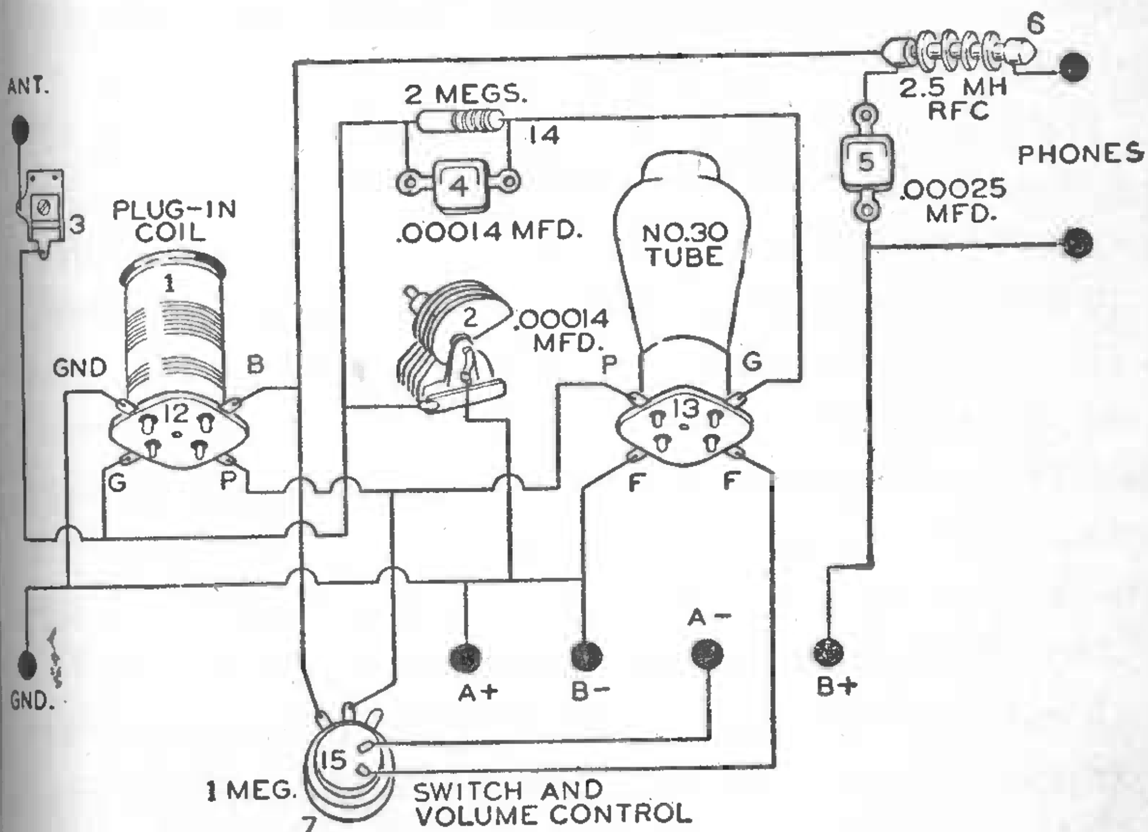
The ground binding post is connected to the A- and B- binding posts, to one filament terminal, F, of the vacuum-tube, and to the rotor of the variable condenser (2).

The larger winding on each plug-in coil is called the *grid coil.* Its terminals are marked GND and G in the illustrations.

The variable condenser (2) is called the *tuning condenser.* It is connected across the terminals of the grid coil, GND and G.

The small winding on each of the plug-in coils is called

PICTORIAL WIRING DIAGRAM
ONE-TUBE BATTERY SET



The parts are numbered to correspond with those on the plan and in the list of parts and materials so that you can identify them. When attaching the batteries, be certain that the positive and negative terminals are connected as indicated. The A battery is the 1½-volt dry cell which supplies current to light the filament of the tube. The B battery (22½ volts) supplies current to the plate circuit of the tube.

the *tickler coil.* The terminals are marked B and P. The regeneration control (7) is connected across the terminals of the tickler coil, B and P.

Only two of the terminals on the regeneration control (7) are used, the center terminal and one other.

One side of the grid leak (14) and the grid condenser

(4) is connected to the stator (fixed plates) of the variable condenser (2). The other terminal of the grid leak and grid condenser is connected to the grid of the vacuum tube—terminal marked G on tube socket (12).

HOW TO OPERATE THE RECEIVER

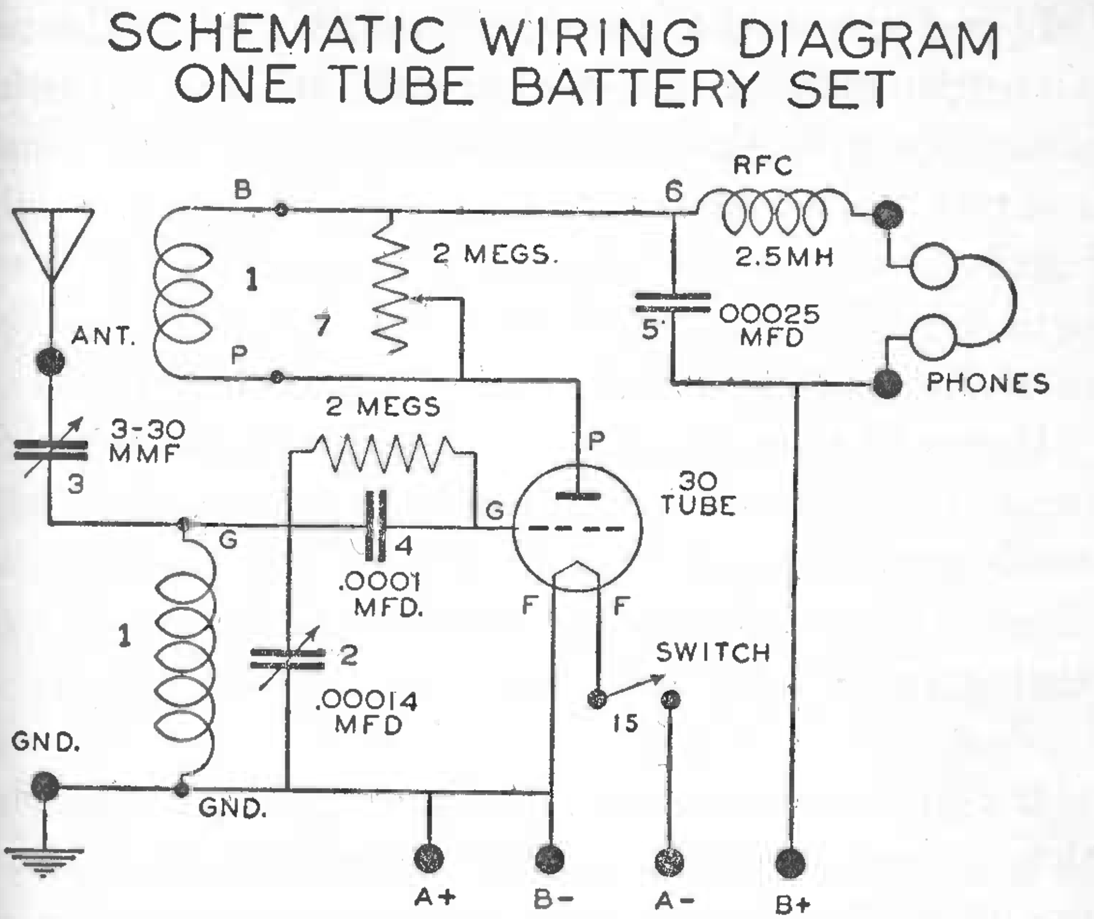
The receiver is tuned by changing the plug-in coils and adjusting the tuning condenser (2). Some adjustment of the antenna condenser (3) may also be necessary. This is explained later.

The regeneration control (15) regulates the regenerative action of the detector tube.

To put the receiver into operation a 1½-volt A battery and a 22½-volt B battery are required. An ordinary No. 6 dry cell will serve as an A battery. B batteries are made especially for radio use and can be purchased from a radio dealer. A small one will do. Be certain that both batteries are fresh. Connect the batteries to the proper posts as shown in the plan. The positive and negative terminals of the batteries must be connected to the right posts as indicated by the plus and minus signs. The center terminal on a No. 6 dry cell is positive. The terminals on B batteries are marked.

The plug-in coils having the fewest turns are for the shortest waves. Those with the most turns are broadcast coils.

Put a broadcast coil and a No. 30 vacuum tube in the



The larger winding on each plug-in coil (1) is called the "grid coil." Its terminals are marked GND and G in the diagram above. The smaller winding is called the "tickler coil" and its terminals are marked B and P above. The radio-frequency choke (6) is labeled RFC. The regeneration control (7) is the 2 Megs. variable resistance. The arrow head indicates that it is variable. When you have completed the wiring check it back against this diagram as well as against the plan.

sockets. Make certain they are in the right sockets. Turn the regenerative control until you hear the filament switch (15) snap. The filament in the tube should light. Turn the regeneration control all the way around and then turn it back half-way.

Connect an antenna about fifty to one hundred feet long and a ground to the proper binding posts. Connect a sensitive telephone receiver or radio head-set to the two binding posts marked PHONES. Slip on the head-phones and turn the tuning condenser until a whistling sound is heard. Then turn the regeneration control back slowly until the whistling ceases. Readjust the condenser very carefully. At this point a signal should be heard.

If no whistling sound is heard in the phones when the regeneration control is rotated half-way and the tuning condenser is moved back and forth, the antenna condenser (3) is probably set up too tight. Loosen the adjusting screw with a screw-driver until the signals are loudest.

If signals are weak and you can not get rid of the whistling sounds when the control is turned back almost to the off position, tighten the adjusting screw on the antenna condenser.

Once the antenna condenser is properly adjusted, no change in it need be made until a different coil is used.

A little experience will soon teach you that broadcasting and amateur phone signals come in best when the regeneration control is set just below the point where whistling is produced.

Code signals come in best just above this point. Incoming "dits and dahs" will tell you that you have a code station.

In working on the short-wave bands, keep the regeneration control just below the whistling point and move the vernier control on the tuning condenser very slowly.

The adjustment of the receiver is not critical except when you want to bring in some real "DX" or distant stations. Distant stations can usually be heard only at night and come in with much greater strength in the winter than they do in the summer.

No trouble should be experienced in getting the receiver to operate if it has been properly wired and connected to antenna, ground, batteries, and phones. If no whistles or signals can be heard after adjusting the set, recheck all connections. See if the filament of the tube is lighted.

Sometimes failure of a receiver of this type to operate is due to the tickler-coil winding being reversed. In that case it will be necessary to reverse the wires attached to the terminals on the coil socket marked B and P in the diagrams. Do not make this change, however, until you are certain that failure of the receiver to regenerate is not due to any other cause.

CHAPTER VII

How to Build Amplifiers

AN AMPLIFIER is simpler to build than a radio receiver. You can assemble and wire a one-stage amplifier in an hour, and the parts will cost less than two dollars.

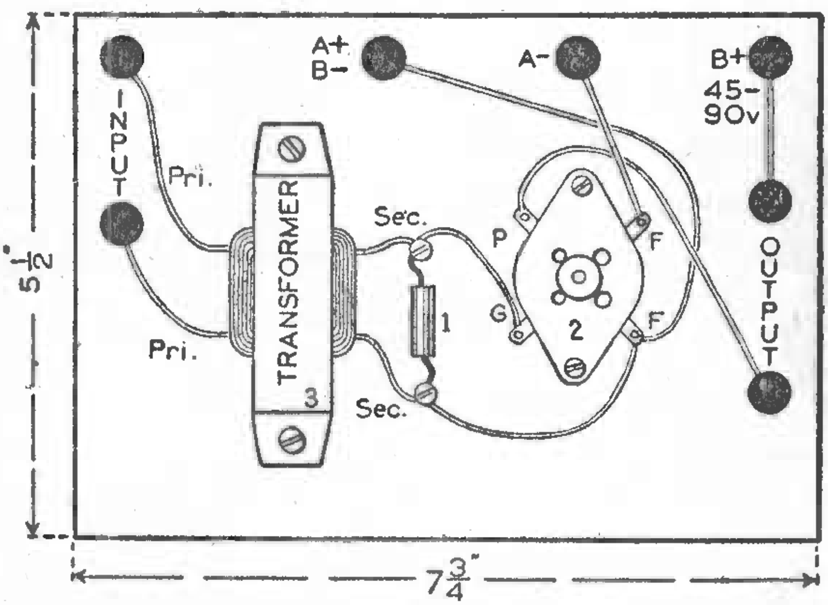
An amplifier will add greatly to the power and range of a crystal detector or a one-tube receiver. It will increase the strength of the sounds in the head-phones. Faint signals, too weak to be heard plainly, can be made quite audible with an amplifier.

Signals which are fairly strong can be so increased in volume that they can be heard with the head-phones lying on the table. Much of the time you can use a speaker in place of the phones.

The speaker which is part of most factory-built broadcast receivers makes it possible for a group of people to listen to the same receiving equipment simultaneously. In principle, a speaker is a large telephone receiver, large enough to produce sounds hundreds of times louder than those sent forth by a telephone receiver. A speaker requires a great deal more energy to operate than does a telephone receiver. A detector alone does not furnish enough energy to operate a speaker. This is true of both crystal and vacuum tube detectors.

But by sending the energy supplied by a detector through the device called an amplifier the energy may be

PLAN
ONE-TUBE AMPLIFIER

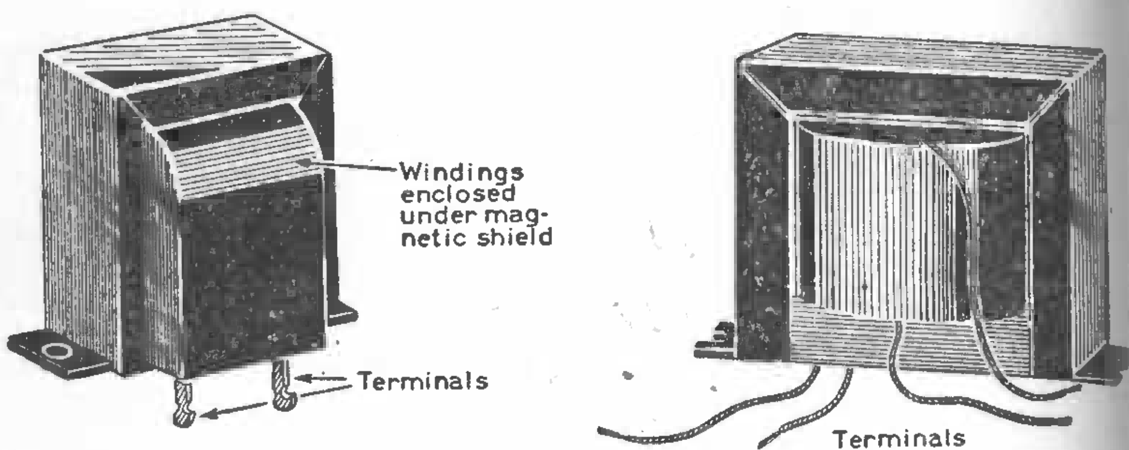


Use a type 30 tube with this amplifier. Sometimes the operation of the amplifier is improved if the secondary terminals of the transformer are reversed. Try changing the transformer terminal connected to socket terminal G from G to F and F from F to G. When you find which way is best, make the connections permanent.

amplified or increased so as to operate a speaker. The same sort of vacuum tube which is used as a detector may be used as an amplifier, but the most efficient amplifier tubes are especially made for that purpose.

TWO KINDS OF AMPLIFIERS

It is possible to use two kinds of amplification to intensify radio signals. Both methods employ a vacuum tube. A *radio-frequency amplifier* amplifies the signals before



AMPLIFYING TRANSFORMERS

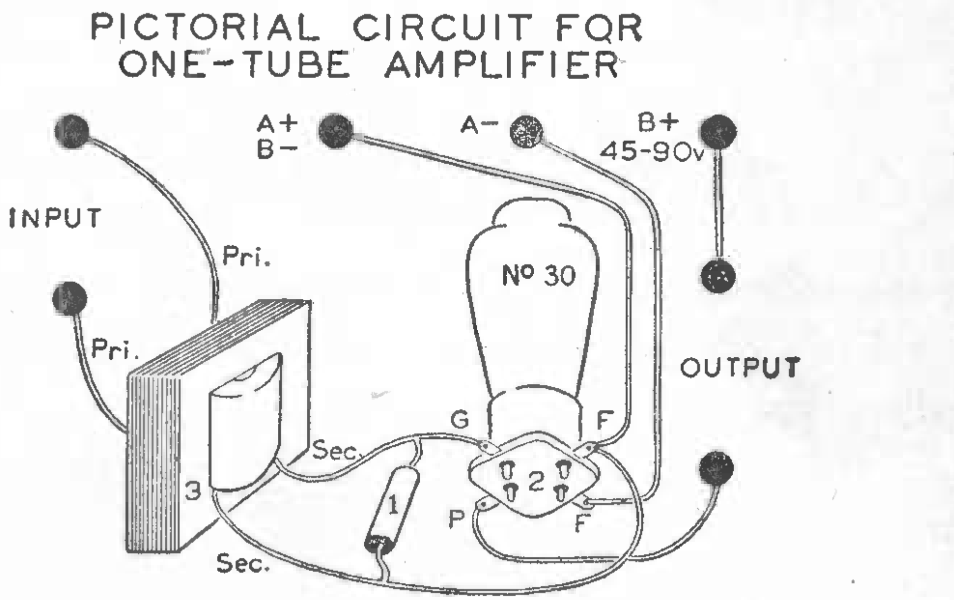
An audio-frequency amplifying transformer consists of two windings: a primary winding and a secondary winding, wound on an iron core. The transformer may or may not be enclosed in a metal shield or case. The transformer at the left in the illustration above is shielded, that at the right is unshielded. Either type is satisfactory for building the amplifiers described in this book.

they are fed into the detector. An *audio-frequency amplifier* increases the energy after it has passed through the detector. Most radio receivers utilizing several tubes employ both kinds of amplifiers.

An audio-frequency amplifier increases currents whose frequency is low enough so that they produce sounds capable of being heard by the human ear. Radio-frequency amplifiers increase currents whose frequency is too high to produce sound that can be heard by the human ear. Audio-frequency amplifiers are used in other fields besides radio. They are employed on long-distance telephone lines; in making phonograph recordings; in talking moving pictures, television, electrical stethoscopes; and for a number of other purposes.

HOW TO BUILD A ONE-STAGE AUDIO-FREQUENCY AMPLIFIER

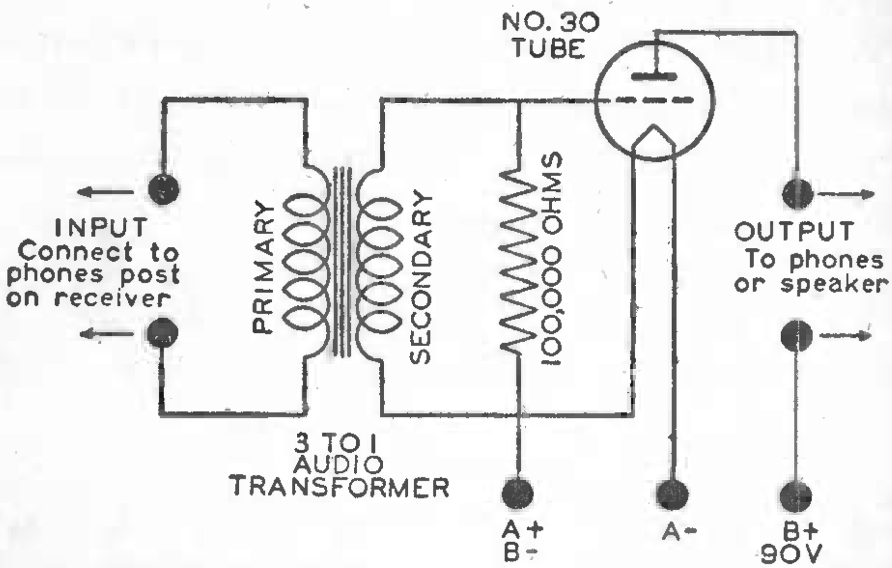
A one-stage audio-frequency amplifier is easiest to build. If its input terminals are connected to the phone



It is a simple matter to build and wire a one-tube, or single-stage amplifier. When connected to a single-tube receiver, the amplifier will greatly increase the strength of the signals.

posts of any of the crystal detector receivers described in Chapters IV and V or the one-tube regenerative receiver described in Chapter VI you will be amazed and pleased

SCHEMATIC CIRCUIT FOR ONE-TUBE AMPLIFIER



The input terminals of the amplifier should be connected to the output or phone binding posts on the receiver, thus replacing the phones. A pair of phones or a speaker is connected to the output terminals of the amplifier. A "B" battery of from 45 to 90 volts should be used on the amplifier. Ninety volts will produce louder signals than 45 volts.

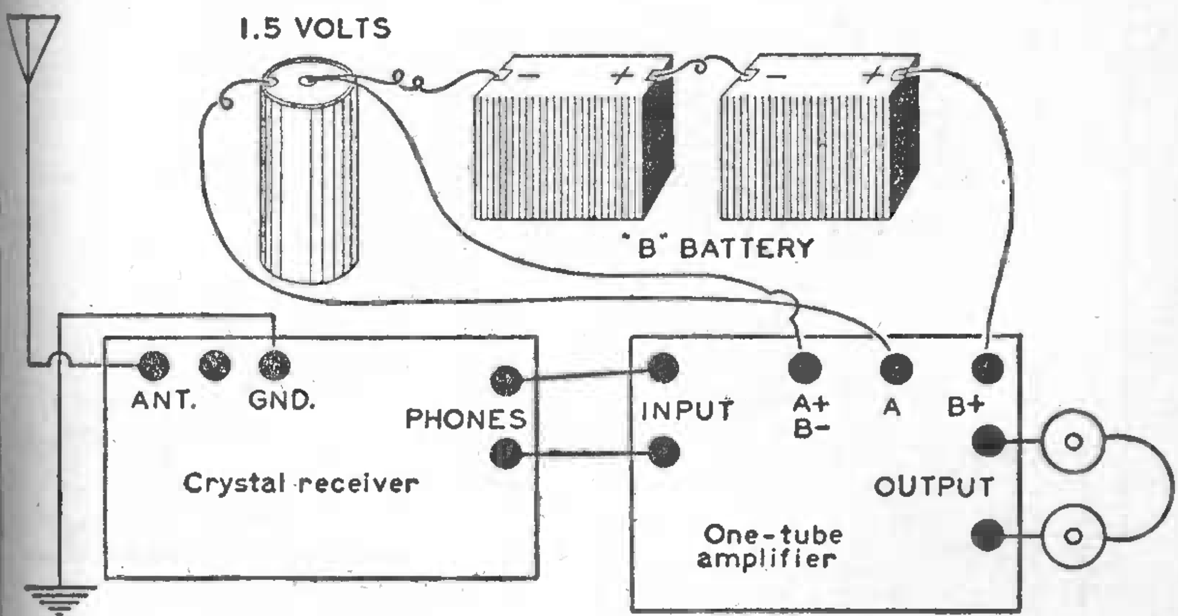
by the increase produced in the strength of signals. In that way a crystal detector or a one-tube receiver can be made to operate a small speaker.

In order to build a one-stage amplifier the following parts are required:

1 Wood base, 7¾" x 5½" x ¾"
1 100,000-ohm, ½-watt resistor (1)
1 4-prong socket (2)
1 3 to 1 radio audio transformer (3)
1 No. 30 radio tube

Their total cost need not be more than $1.75.

An audio-frequency transformer usually consists of an iron core upon which is wound a primary coil of fine wire, and on top of this, a secondary of fine wire. Usually, there are from 2½ to 3½ times as many turns of wire in the secondary coil as there are in the primary. There are four



HOW TO CONNECT A CRYSTAL RECEIVER TO AN AMPLIFIER

An amplifier will greatly increase the strength of the signals produced by a crystal detector. The pictorial circuit diagram above shows how to connect a crystal receiver to a one-tube amplifier. The batteries play no part in the operation of the crystal detector. Their energy is utilized solely by the amplifier.

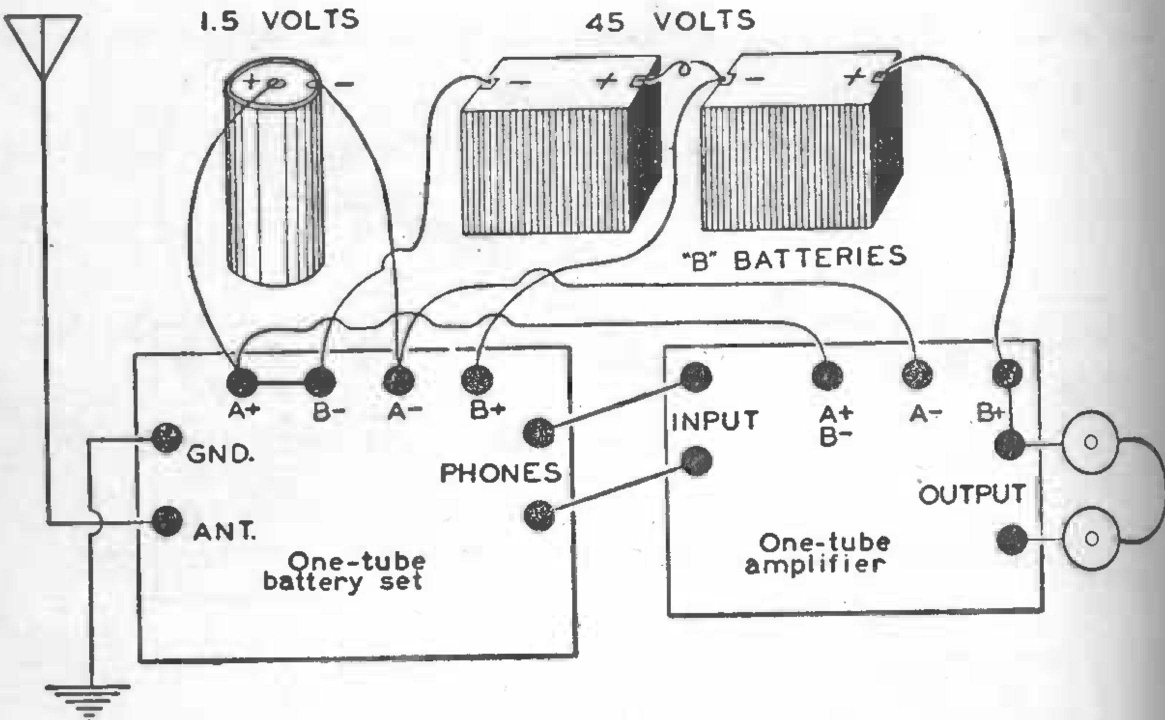
terminals on the transformer. Two are primary terminals and two are secondary terminals.

The base upon which the parts are assembled should be a piece of dry white pine 7¾" x 5½" x ¾" which has been shellacked or varnished.

The parts should be mounted on the base as shown in the plan.

Wiring is simple. Consult both the schematic and the pictorial circuit diagrams. Use push-back wire and rosin-core solder.

The amplifier does not require any tuning or adjust-



HOW TO CONNECT THE ONE-TUBE AMPLIFIER TO THE ONE-TUBE RECEIVER

The headphones are connected to the OUTPUT terminals of the amplifier. The INPUT terminals of the amplifier are connected to the PHONES terminals of the receiver. The same batteries provide current for both the receiver and the amplifier.

ment. Put a No. 30 radio vacuum tube in the socket, and it is ready to use. Current for the filament of the tube is supplied by a 1½-volt dry cell. The B current is furnished by two 22½-volt or one 45-volt B battery. It is necessary for the positive and negative terminals of the B battery to be connected to the proper posts.

The circuit diagrams show how to connect the batteries to the amplifier and how to connect the amplifier to a crystal receiver and the one-tube battery-operated regenerative receiver. These show only the external connections and are known as "block" diagrams.

The output terminals of the amplifier may be connected to a pair of head-phones or to a small speaker of the permanent magnet type.

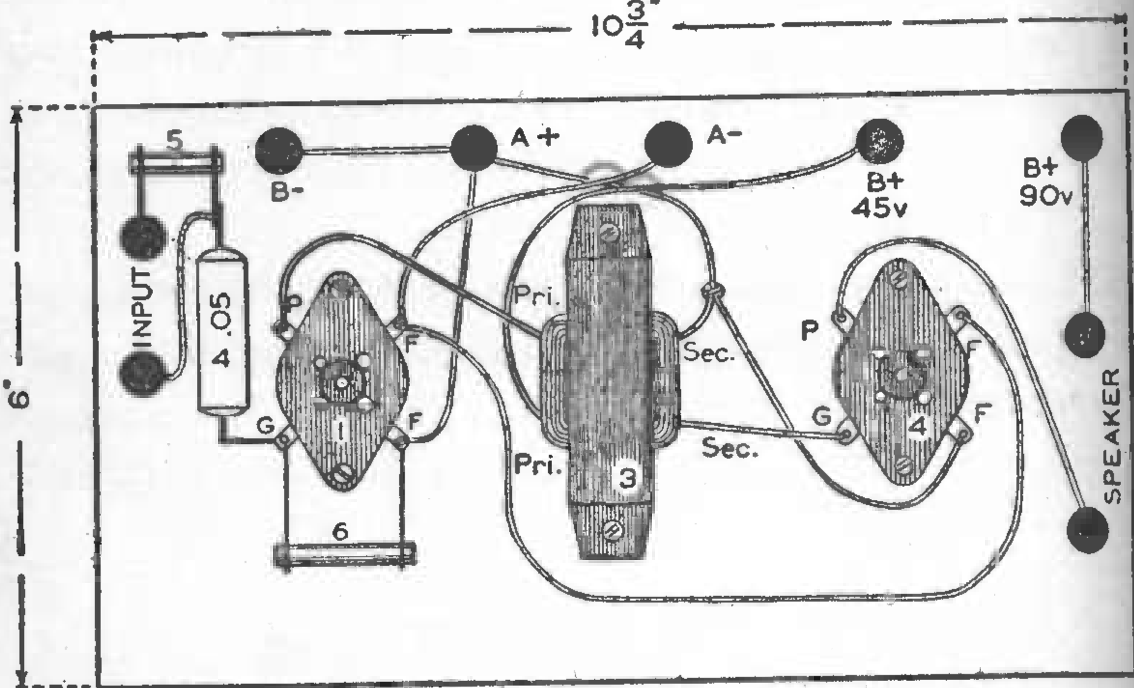
When the amplifier is not in use, disconnect the batteries.

HOW TO BUILD A TWO-STAGE AUDIO-FREQUENCY AMPLIFIER

A two-stage amplifier amplifies much more than a one-stage. In a one-stage amplifier, the amplifying process takes place once. In a two-stage amplifier, it takes place twice. A faint signal, so weak as to be barely audible in the head-phones, can be strengthened by a two-stage amplifier so that it will come out of a speaker with good volume.

There are two methods of coupling an audio-frequency amplifier to a detector or to another amplifier. One method, called *resistance coupling*, uses a resistance unit. The other employs a transformer and is called *transformer*

PLAN FOR TWO-STAGE AUDIO-FREQUENCY AMPLIFIER



A two-stage amplifier will produce much louder signals than a one-stage. It will operate a loud speaker.

The two-stage amplifier shown in the above plan can be connected to any of the receivers described in this book and the head-phones replaced with a speaker.

The first stage of this amplifier does not utilize any transformer. It is coupled to the detector by the resistance marked 5. The second stage is transformer (3) coupled to the first stage.

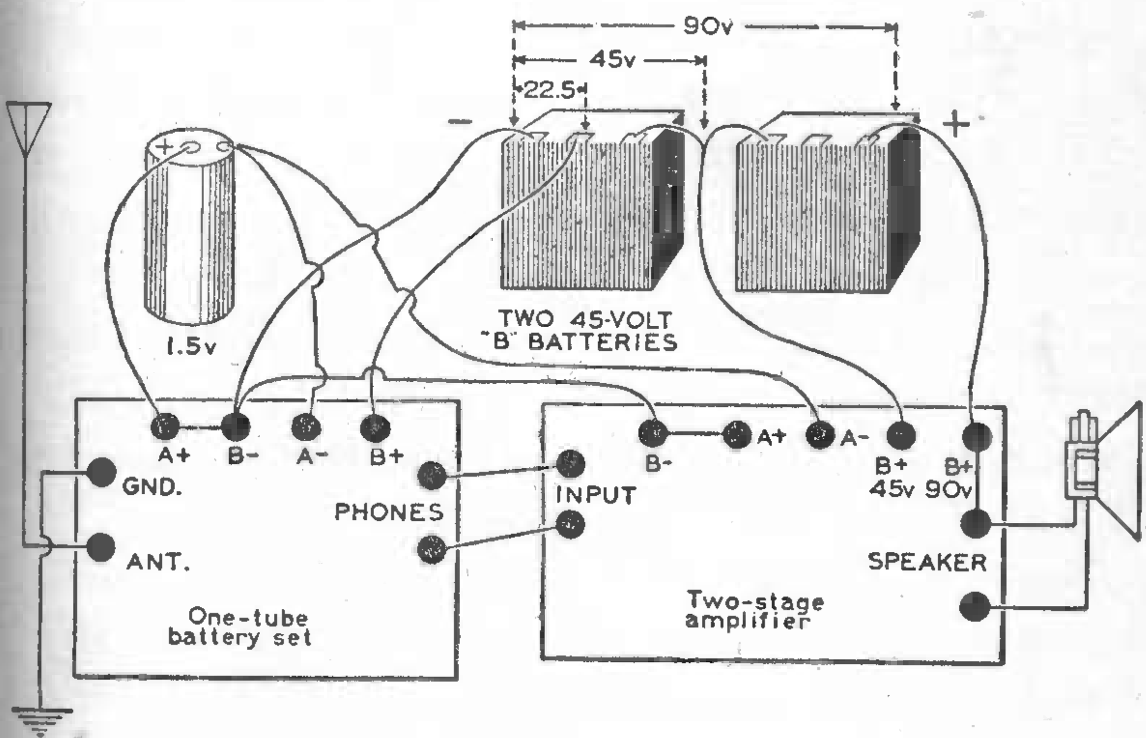
coupling. The one-stage amplifier already described in this chapter utilizes transformer coupling.

The two-stage amplifier shown on this page uses resistance coupling in the first stage and transformer coupling in the second stage.

The following parts are required in order to assemble the amplifier:

1 Wood base 9" x 5½" x ¾"
2 No. 30 vacuum tubes
2 4-prong sockets for No. 30 tubes
1 Audio-frequency transformer (ratio 2½ to 1 or 3 to 1)
1 .05 Mfd. tubular paper condenser
1 50,000-ohm ¼-watt resistor
1 500,000-ohm ½-watt resistor
8 Binding posts or terminals

The wood base should be dry and should be given a coat of varnish or shellac. Arrange the parts on the base as shown in the plan. Connect with push-back wire. Solder



HOW TO CONNECT THE ONE-TUBE BATTERY SET TO THE TWO-STAGE AMPLIFIER

The same batteries supply current to both the receiver and the amplifier. One of the 45-volt B batteries is tapped so that 22½ volts are supplied to the detector.

all connections with rosin-core solder. The circuit is simpler than that of a receiving set. Consult both the plan and the schematic circuit diagram, and check each connection with a pencil mark as the wire is put in place.

When the amplifier has been wired and checked, it is ready to use. Place a No. 30 tube in each of the sockets. Connect the input terminals on the amplifier to the terminals marked PHONES on the receiver. Connect a small permanent magnet-type speaker to the terminals marked SPEAKER.

In order to obtain full volume from the speaker it will be necessary to use a B battery of ninety volts. Four 22½-volt batteries or two 45-volt batteries connected in series will supply this voltage. The first stage requires only forty-five volts. The full voltage of ninety is used on the last stage. One of the diagrams shows how to connect the amplifier to a crystal receiver. A second diagram shows how to connect the amplifier to a one-tube receiver. The A battery furnishes current for both. So does one of the B batteries.

CHAPTER VIII

Building Your First Receiver for 110 Volts

BY FIRST building crystal receivers and battery-operated vacuum tube receivers, you gain valuable experience which will enable you to build 110-volt operated receivers without possibility of harm to radio parts or to yourself.

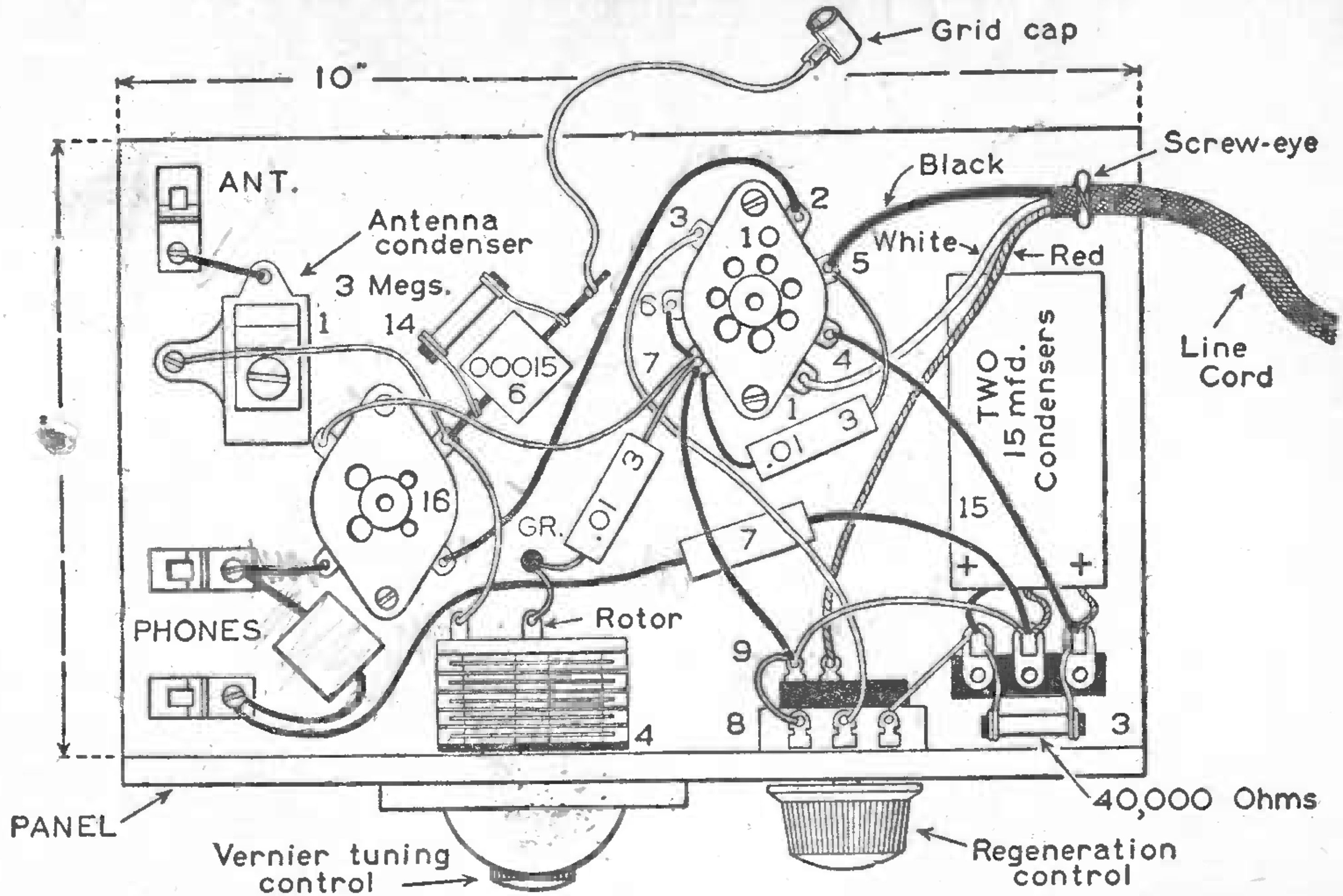
If you know something about electric currents and can connect the parts of a receiver by consulting a circuit diagram without making mistakes, you are ready to build a receiver operated from the 110-volt house current.

THE ONE-TUBE "CLOUD-HOPPER"

This is a dependable one-tube 110-volt operated short-wave receiver which can be built quickly and easily.

It requires no ground connection. Plug into the nearest 110-volt outlet, connect the antenna, and it is ready. Using the proper plug-in coils, you can tune in all the broadcast stations that you would ordinarily get on your regular home radio. A standard set of broadcast coils covers the broadcast band which extends from 550 to 1500 kilocycles or 545 to 175 meters. This section of the radio spectrum is set aside for regular commercial radio

PLAN FOR ONE-TUBE "CLOUD HOPPER"



The small black circle marked GR represents a hole through the base and the sheet metal on the bottom. The wires from the rotor and the condenser (3) which apparently end at the hole actually go through the base and are soldered to the metal sheet.

broadcasting and chain programs in the United States.

With a set of short-wave coils, you can listen to another portion of the radio waves. The range from about 16 to about 217 meters is covered by four separate plug-in coils. With them you can tune in amateur stations in the United States and other countries, airplane and short-wave police calls, commercial radiophone transmission, ships at sea, and foreign short-wave stations.

It is not practical to receive waves shorter than 16 meters with the "Cloud Hopper"; a short-wave receiver built for short wave lengths is necessary.

The "Cloud-Hopper" uses a single No. 12A7 tube. The heaters of the tube may be lighted from the 110-volt current when used with a 360-ohm line cord resistor. The resistance built in the cord reduces the current to the proper value for the tube and no A battery is necessary.

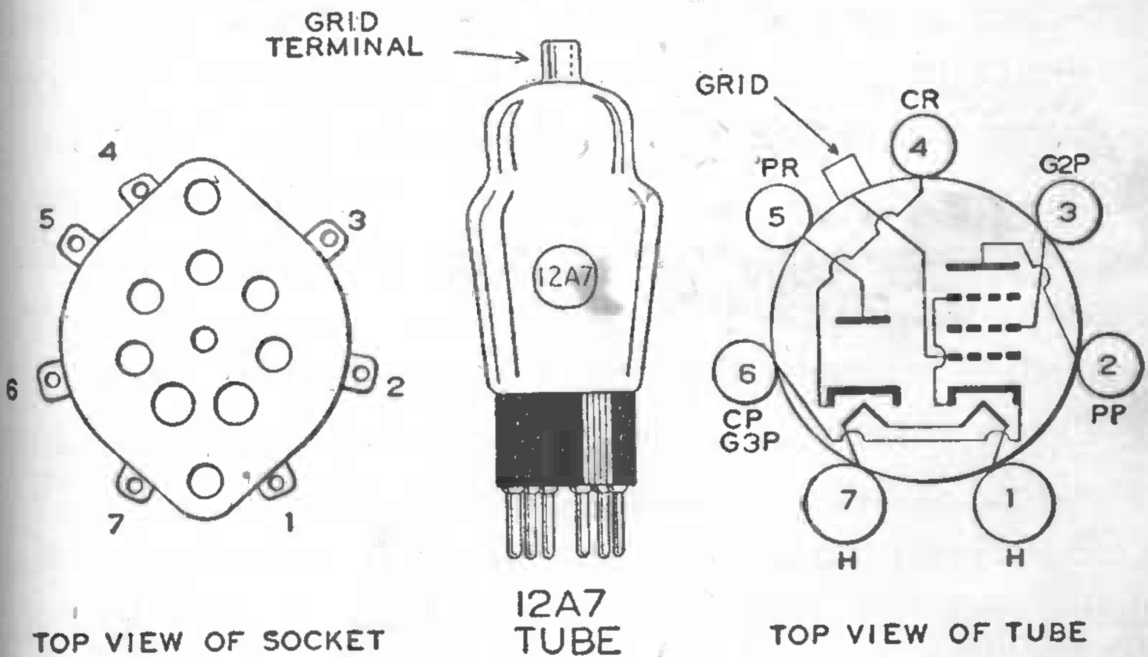
A No. 12A7 is really two tubes in one. That is why it has so many prongs on the base (seven). In addition to the heater, cathode grid, screen grid and plate of a detector it includes the heater, cathode and plate of a rectifier. The rectifier portion of the tube rectifies or changes the 110-volt alternating current into direct current so that it can be used in place of a B battery.

To build the "Cloud-Hopper" you will need the parts and materials listed below.

1 *Wood base 9″ x 6½″ x ¾″*
1 Piece sheet metal, 8″ x 6″

1 Plywood panel, 9" x 5½" x ¼"
1 3–30 Mmfd. Trimmer Condenser (1)
1 4-prong socket (2)
3 .01 Mfd. 400-volt tubular paper condensers (3)
1 100 Mmfd. Variable Condenser (4)
1 Vernier dial (5)
1 .00015 Mfd. mica condenser (6)
1 .002 Mfd. mica condenser (7)
1 50,000-ohm volume control (8) and switch (9)
1 12A7 Radio tube (10)
1 7-prong type FF socket for 12A7 tube (11)
1 Grid cap (12)
1 40,000-ohm, ½-watt resistor (13)
1 3-megohm, ¼-watt resistor (14)
1 4–4 Mfd. 250-volt double section electrolytic condenser (15)
1 Set 4-prong broadcast coils (16)
1 Set 4-prong short-wave coils (16)
1 360-ohm line cord resistor (17)
3 Binding posts
1 .1 Mfd. 200-volt tubular condenser
Screws, push-back wire, etc.

First make a wooden base, 9" x 6½" x ¾". Shellac or varnish the sides, ends, top and bottom so as to make it moisture-proof and prevent it from warping. Then attach an 8" x 6" metal sheet to the underside with several small wire nails. If you use a round-headed upholsterer's nail at each corner, they will raise the base so that the metal sheet will not scratch any table or desk that the receiver may rest upon. The metal sheet may be thin galvanized iron or sheet-tin. You can cut a piece from an old one-gallon can or buy a piece at a plumbing shop. The metal sheet is necessary in order to provide a "ground" for the circuit. The variable tuning condenser and one of the fixed paper condensers are shown in the circuit diagram to have one



The 12A7 type of tube has seven prongs on its base. The grid terminal is a metal cap on the top of the tube. In order to establish connection with the grid terminal, a grid clip is necessary. This device is shown in another illustration.

terminal "grounded." This means that they are connected to the metal sheet on the underside of the base.

The various parts which make up the receiver, with the exception of the variable tuning condenser and the regeneration control, are mounted on the wooden base in the relative position shown in the plan.

The plywood panel should be shellacked or varnished on both sides and fastened to the front edge of the base.

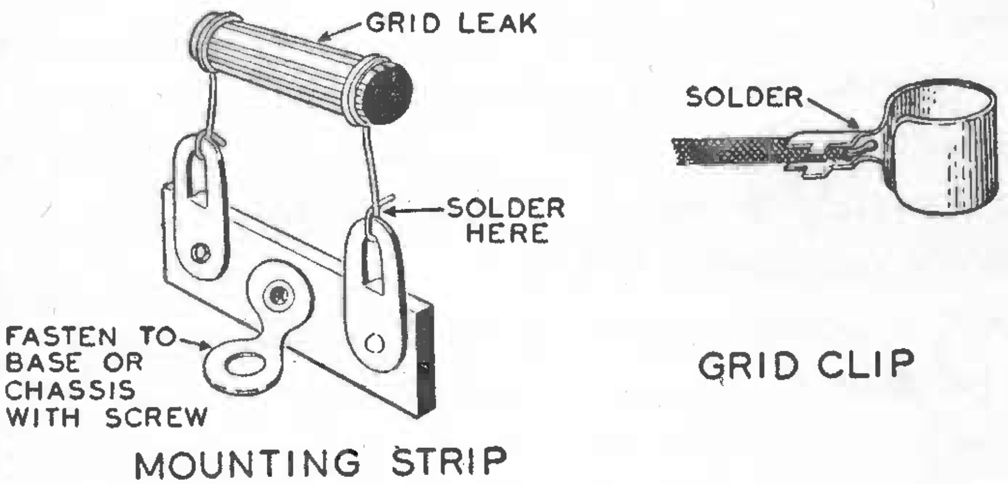
The volume control, which serves as the regeneration control, and the tuning condenser are mounted on the back of the panel. The vernier dial and the regeneration control knob are on the front of the panel. The tuning is not close or critical when you are listening to broadcast stations and the condenser does not have to be accurately adjusted. Any sort of dial and knob will serve. When tuning short waves, it is a different story. The condenser must be accurately adjusted. A very small movement of the rotor plates will tune a short wave station in or out. Consequently a vernier dial is necessary for short waves.

The parts should all be fastened in place before any wiring is done. The wires are shown in the plan. The schematic circuit diagram should also be consulted. Make the connections with the utmost care. As each wire is soldered in place, check it on the diagram with a pencil so that none are overlooked. Follow the rule used in wiring all radio apparatus: use rosin-core solder.

In order to connect one terminal (the rotor) of the variable condenser and one terminal of the fixed condenser which are shown to be "grounded" in the schematic circuit diagram, drill two small holes through the base and the metal sheet. Slip a wire from the condenser through the hole and solder to the underside of the metal sheet. In the illustration showing the plan of the set, these wires are marked G where they pass through the holes in the set.

In the plan the terminals of the tube socket are numbered so that you can easily identify them with the schematic circuit diagram.

The grid on a No. 12A7 tube is connected to a terminal

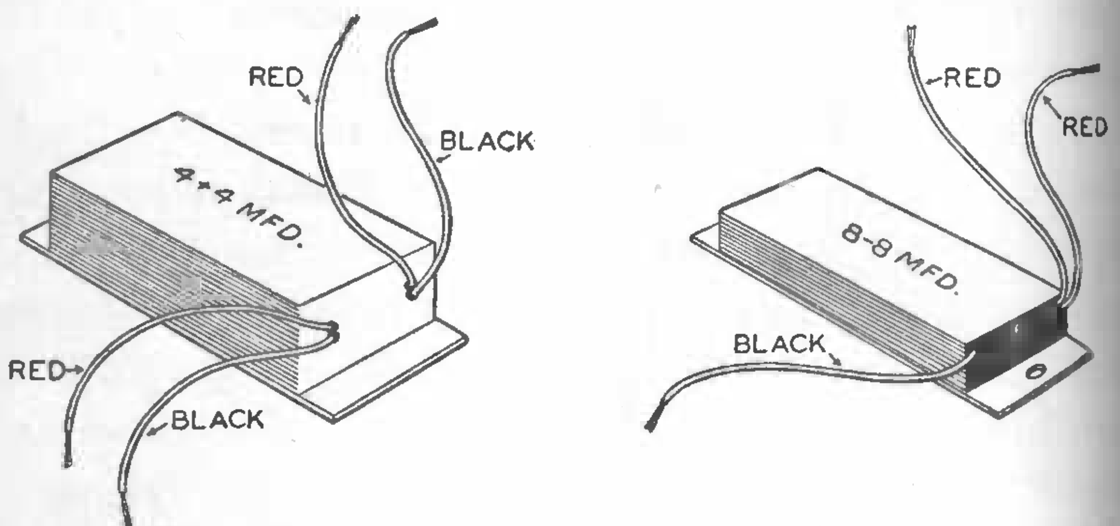


Mounting strips are handy for supporting grid leaks, resistors and small condensors. A grid clip is necessary in order to make connection to tubes whose grid terminal is a grid cap.

on top of the bulb. You will need a grid "cap" which will fit this terminal. Solder a wire to the cap and make it long enough so that it will reach one terminal of the grid condenser and grid leak.

Eight terminals on a tube will make the circuit and the wiring appear very complicated to the novice. Actually it is simple. Work slowly and carefully, make certain each connection is properly made, and you will probably not have any trouble assembling the "Cloud-Hopper."

The line cord resistor is anchored by tying it to a screw eye in the base. There does not seem to be any standard color code for marking the wires in line cord resistors. The cord which the author used in making the original model of the "Cloud-Hopper" consisted of a red, a white, and a black wire. The red wire contained the resistance. The



DRY ELECTROLYTIC CONDENSERS

Both these condensers are "double," that is, consist of two condensers within one case. Double condensers may have four terminals or three. Terminal wires are red and black. The red wire is positive and is sometimes marked positive or with a plus sign. All the circuit diagrams in this book are marked so as to show the positive terminal of the electrolytic condensers. A plus sign is used as the mark; when the condenser is connected in circuit the polarity must be observed.

red and the black wires were connected together at the plug.

When wiring the receiver, notice that the double-section 4-4 Mfd. electrolytic condenser has both red and black terminal wires. The red terminals are marked with a plus sign in the circuit diagram and on the plan.

When all connections have been made and checked, the receiver is ready for testing.

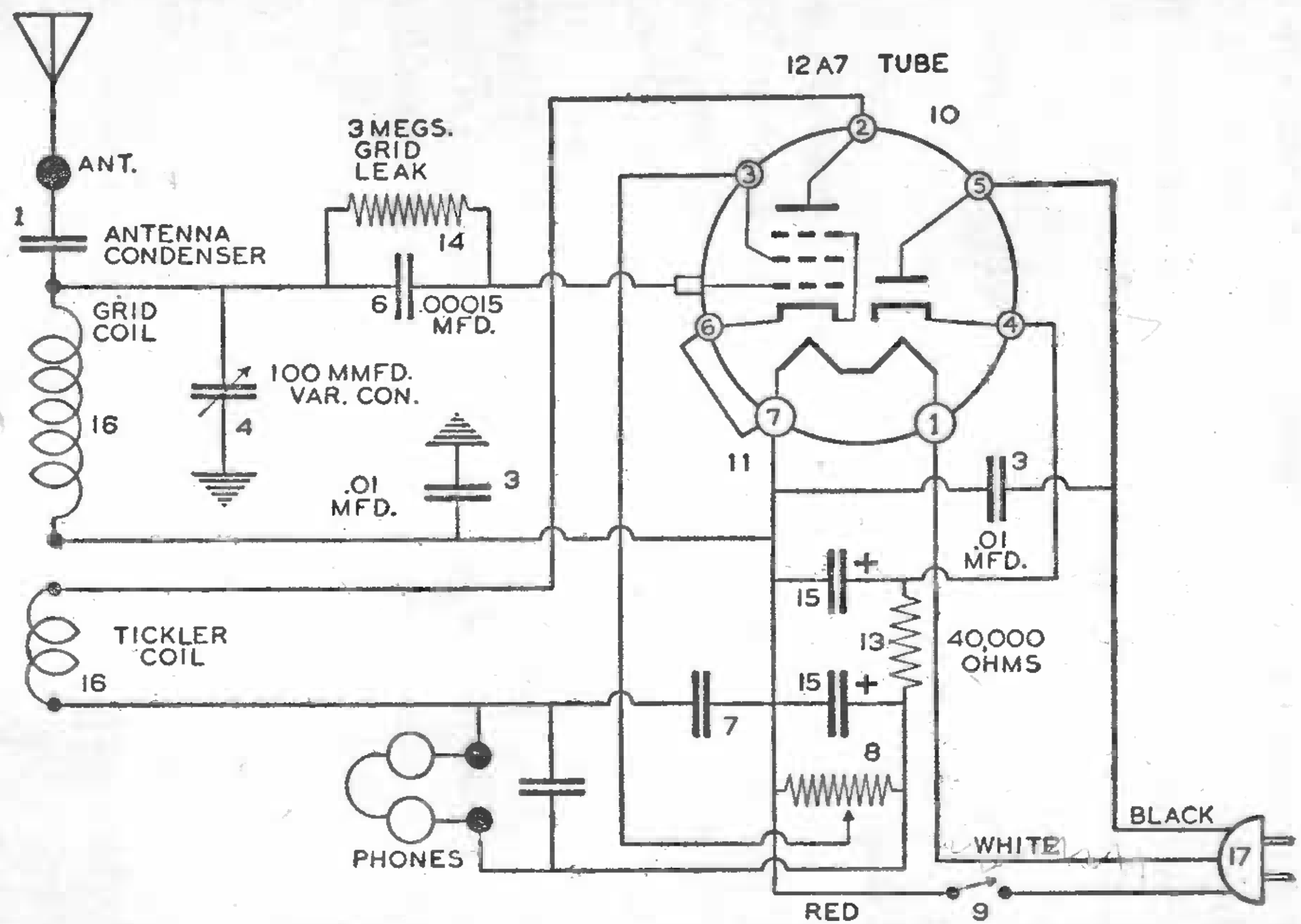
Place the No. 12A7 tube in its socket and slip the grid cap on the terminal at the top of the tube. Place a broadcasting plug-in coil in the four-prong socket. Connect the antenna to the antenna binding post and plug the line cord resistor into a 110-120-volt outlet. Connect a set of head-phones to the PHONES terminals.

Turn the regeneration control knob so that the switch is closed and the tube lights. Slip on the head-phones and turn the regeneration control still more to the right until, as the variable tuning condenser is rotated slowly, you hear a series of whistles and squeals in the phones. You may also have to adjust the antenna trimmer condenser slightly with a screw-driver in order to achieve this condition. The whistling can be cleared up and broadcasting signals brought in by a slight adjustment of the regeneration control and tuning condenser.

Failure of the set to operate, provided you are using a good tube, will probably be due to a mistake in wiring. If you can not produce any squeals or whistles in the phones, the set is not regenerating. Sometimes failure of the receiver to regenerate is due to a reversed winding on the tickler coil. If you are certain that failure of the receiver to regenerate is not due to any other cause, reverse the connections T and T on the coil socket.

Each time that one of the plug-in coils is changed, it will be necessary to readjust the antenna trimmer condenser.

SCHEMATIC CIRCUIT FOR ONE-TUBE "CLOUD HOPPER"



This receiver can be much more compact than is shown in the plan. In order not to confuse the wiring, the parts are shown spaced farther apart than is necessary. The condenser marked 7 should have a capacity of .002 Mfd. The condenser connected across the phones should have a capacity of .001 Mfd.

When a whistling sound is produced in the phones, the detector is *oscillating*. The antenna condenser should be adjusted so that by turning the regeneration control, you can make the set whistle or oscillate at any point on the dial. Once the antenna condenser is adjusted properly, it should not be changed until a different coil is used.

Amateur phone stations come in best when the regeneration control is adjusted just below the point where whistles are heard. Telegraph signals come in best just above this point. Radio reception is much better at night than it is during daylight. Low-powered amateur stations sending out waves 10 to 42 meters in length (or frequency of 30,000 to 7,000 kilocycles) can communicate amazing distances during the night hours.

You will soon learn how to tune the "Cloud-Hopper" and with a little practice be able to pick up stations from an amazing distance. Long-distance radio reception is almost always better during the winter than during the summer.

HOW TO BUILD A 2-TUBE A.C.-D.C. REGENERATIVE RECEIVER

This is also a good model to choose as your first venture in building a receiver operated on the 110-volt house lighting current. It will operate on either alternating or direct current. Although two tubes are utilized and at first the circuit looks complicated to the novice, it is easier to wire than the "Cloud-Hopper." There is less chance of making a mistake in the socket connections.

In the "Cloud-Hopper" a detector and a rectifier for supplying direct current to the detector are combined in one tube. The tube consequently has eight terminals. In this model two No. 76 radio tubes are used. One tube acts as a detector, the other as a rectifier which changes the alternating current supply to direct current to operate the detector. No. 76 tubes have four elements: a heater, a cathode, a grid, and a plate. The base is provided with five prongs and fits a standard five-prong socket.

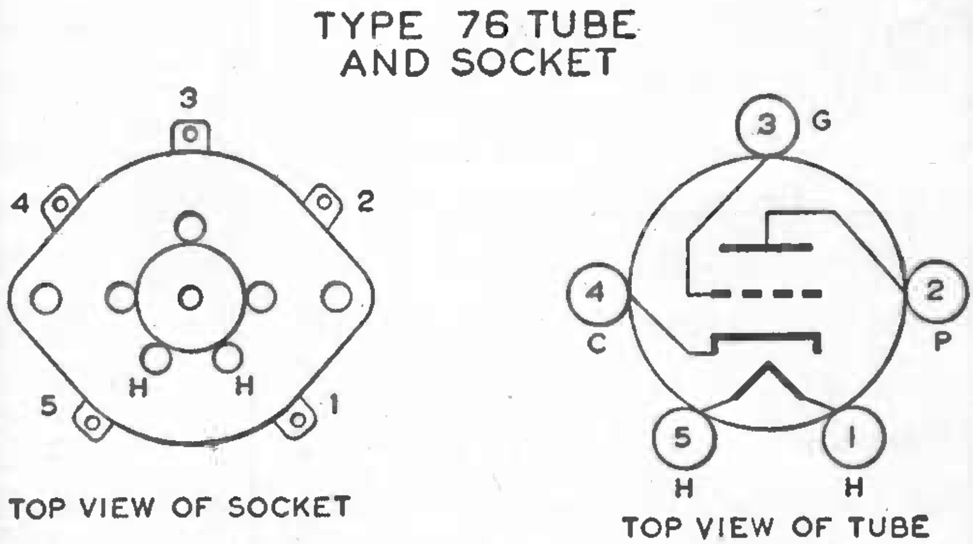
This receiver is simple to operate. There are only two variable controls, the tuning condenser and the regeneration control. By means of a set of five standard four-prong plug-in coils, a complete range of wave-lengths from 17 to 545 meters may be covered. No ground connection is used, but an antenna is necessary.

In selectivity, wave-length range, and distance-getting ability this set and the "Cloud-Hopper" are equals.

Notice that no panel is shown in the plan. If you are interested in tuning in broadcast stations only, you can mount the tuning condenser directly on the base and use a bracket to support the regeneration control. A vernier control on the tuning condenser is not necessary.

But if you wish to tune in short-wave stations, the tuning condenser must be accurately adjusted and a vernier control is necessary. A panel is required to support the condenser.

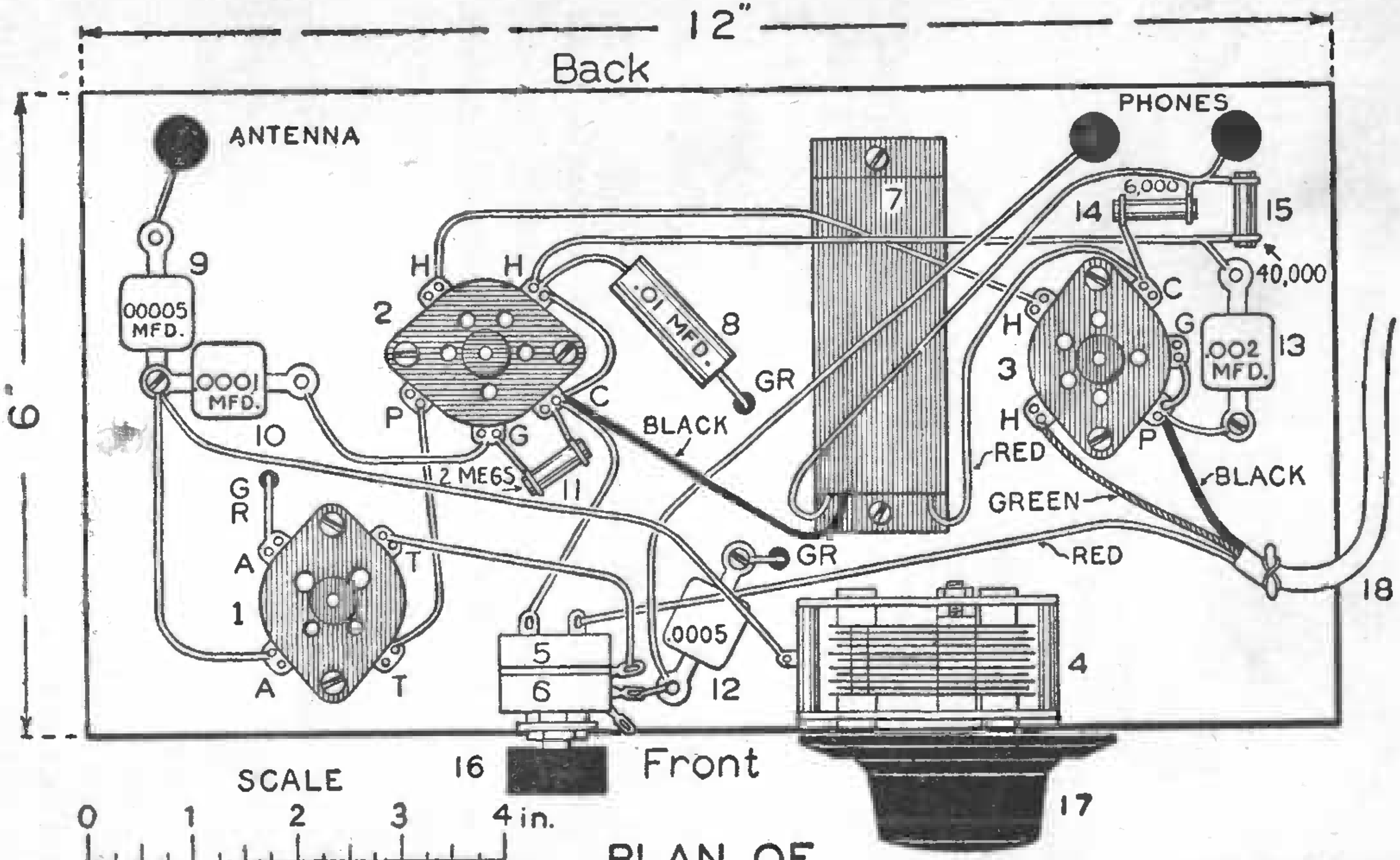
You will need the parts and materials listed below. Some of these have been keyed or numbered in the list so



The type 76 tube has five prongs, all of the same size. The prongs are not spaced evenly and there is only one position in which the tube can be slipped into the socket.

that you can identify them in both the schematic circuit and the wiring diagram.

1 Wooden base, 12″ x 6″ x ¾″
1 Plywood panel 12″ x 5½″ x ¼″
1 Piece sheet metal 11″ x 5″
1 4-prong wafer socket for plug-in coils (1)
2 5-prong wafer sockets for No. 76 tubes (2 and 3)
2 Type 76 tubes
1 .0001 Mfd. variable tuning condenser (4)
1 3-inch dial and knob for tuning condenser (17)
1 10,000-ohm potentiometer or volume control (6) with switch (5) and control knob (16)



PLAN OF
2-TUBE AC-DC REGENERATIVE RECEIVER

The wires pass through the holes and are soldered to the metal sheet. A plain condenser tuning knob and dial are shown in this sketch. This will be satisfactory for tuning broadcasting stations, but if you wish to tune in short waves it is advisable to equip the receiver with a vernier control.

1 Double section 8–8 Mfd. cardboard case, dry electrolytic condenser (7)
1 .01 Mfd. tubular condenser
1 .00005 Mfd. mica condenser (9)
1 .0001 Mfd. mica condenser (10)
1 .005 Mfd. mica condenser (12)
1 .002 Mfd. mica condenser (13)
1 2-megohm grid leak or ¼-watt resistor (11)
1 6,000-ohm, ½-watt resistor (14)
1 40,000-ohm, ½-watt resistor (15)
1 330-ohm line cord resistor (18)
3 Binding posts or terminals
Screws, push-back wire, etc.

Shellac or varnish the sides, ends, top, and bottom of the wooden base so as to make it moisture-proof. The metal sheet is then attached to the underside with several small wire nails. The sheet is 5″ x 11″, not quite as large as the base. It may be thin galvanized iron or sheet-tin. You can get a piece at a plumbing shop or perhaps cut it from an old one-gallon can. The purpose of the metal sheet is to provide a "ground" for the grid coil, control resistance, tuning condenser, etc., as shown in the circuit diagram. The black dots marked GR on the plan, where a wire apparently ends, represent holes drilled through the wooden base and metal sheet on the bottom. The wires pass through the holes and are soldered to the metal sheet.

The various parts which make up the receiver are mounted on the wooden base in the relative positions shown in the plan on page 138. A four-inch scale is shown in the lower left-hand corner of the illustration. If this is traced on a piece of paper, it may be used to measure the distances on the plan. The parts shown on the plan are spaced farther apart than is actually necessary. This was done in order to make the wiring easier to understand.

The three sockets are mounted on small spacers which raise them up from the base. The variable condenser and the potentiometer are at the forward edge of the base so that they are convenient to adjust. The condenser is fastened in place by two screws which pass through the wooden base from the underside. The potentiometer is mounted in a small bracket bent out of sheet metal as shown in one of the illustrations.

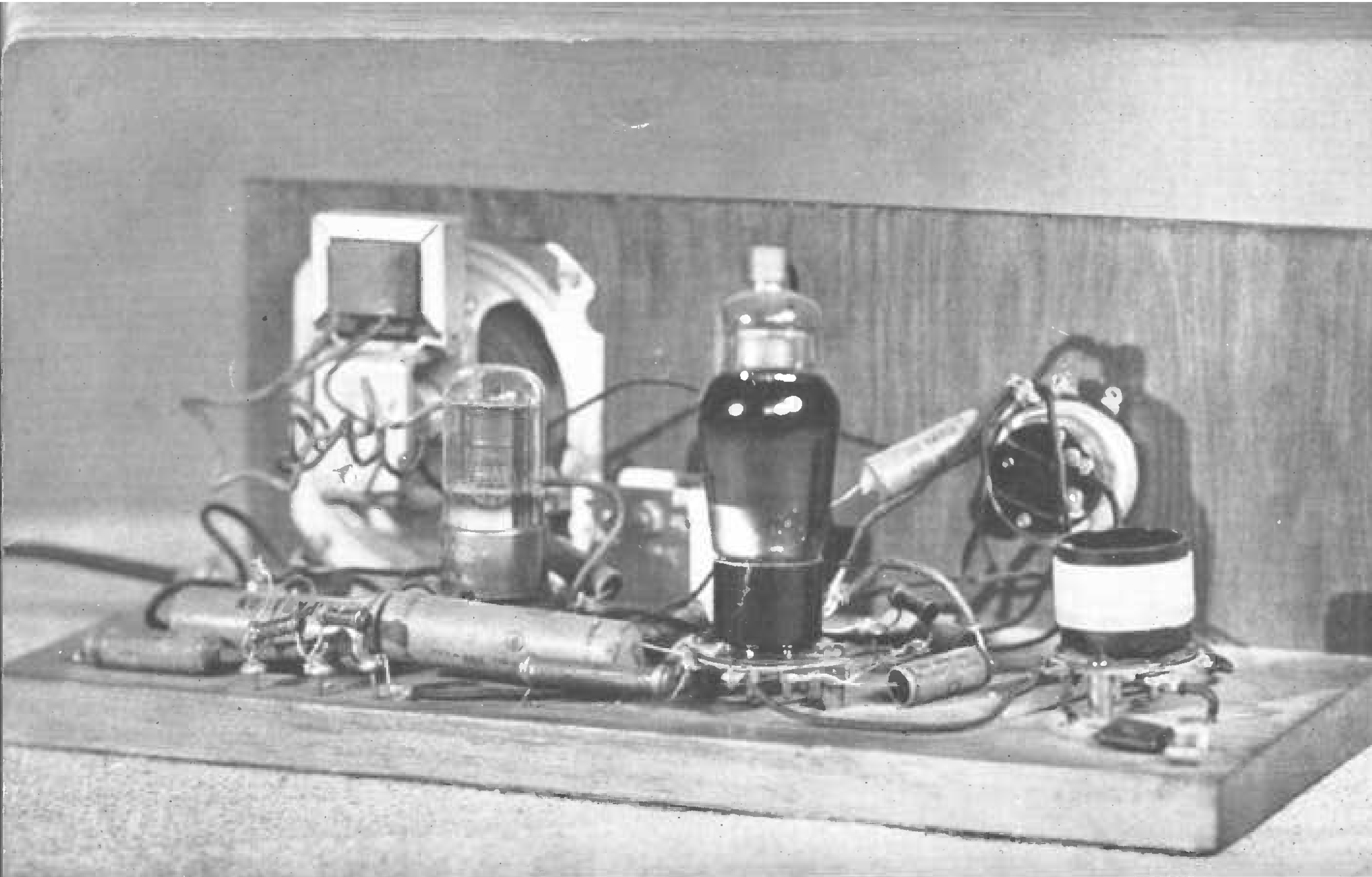
When the parts have been fastened in place, the set is ready for wiring. The connecting wires are shown in the plan. The schematic circuit diagram should also be consulted. Follow the connections with the utmost care. As each wire is soldered in place, check it on the diagram with a pencil. Then none will be overlooked. Have the soldering iron hot and keep it clean. Use only rosin-core solder and push-back wire. After completing the wiring, check it carefully.

Here are some facts and explanations of the circuit which may help in wiring.

The frame and the rotating plates of the variable con-

A one-stage audio-frequency amplifier. This device will greatly increase the signal strength of any of the receivers described in this book.

The 2-tube A.C.–D.C. regenerative receiver.



Rear view of the 2-tube A.C.–D.C. receiver with speaker.

denser (4) are grounded to the metal sheet on the bottom of the base.

One terminal of the grid or antenna coil (19) is grounded to the metal sheet on the bottom of the base. The other terminal of the coil is connected to the grid condenser (10). The other terminal of the grid condenser (10) is connected to the grid terminal on the detector tube socket (2).

The 2-megohm grid leak (11) is connected across the grid and plate terminals of the detector tube socket (2).

In the illustration showing the plan of the set, wires leading to the metal sheet pass through holes in the base and are marked G.

Notice that only the center and one outside terminal on the potentiometer (6) are used.

On the plan, the terminals of the four-prong socket (1) to which the grid or antenna coil (19) will be connected when the coil is plugged in are marked A and A. The terminals of the grid coil (20) are marked T and T.

The small mica condensers are fastened to the base by a screw passing through the eye in one of the terminals.

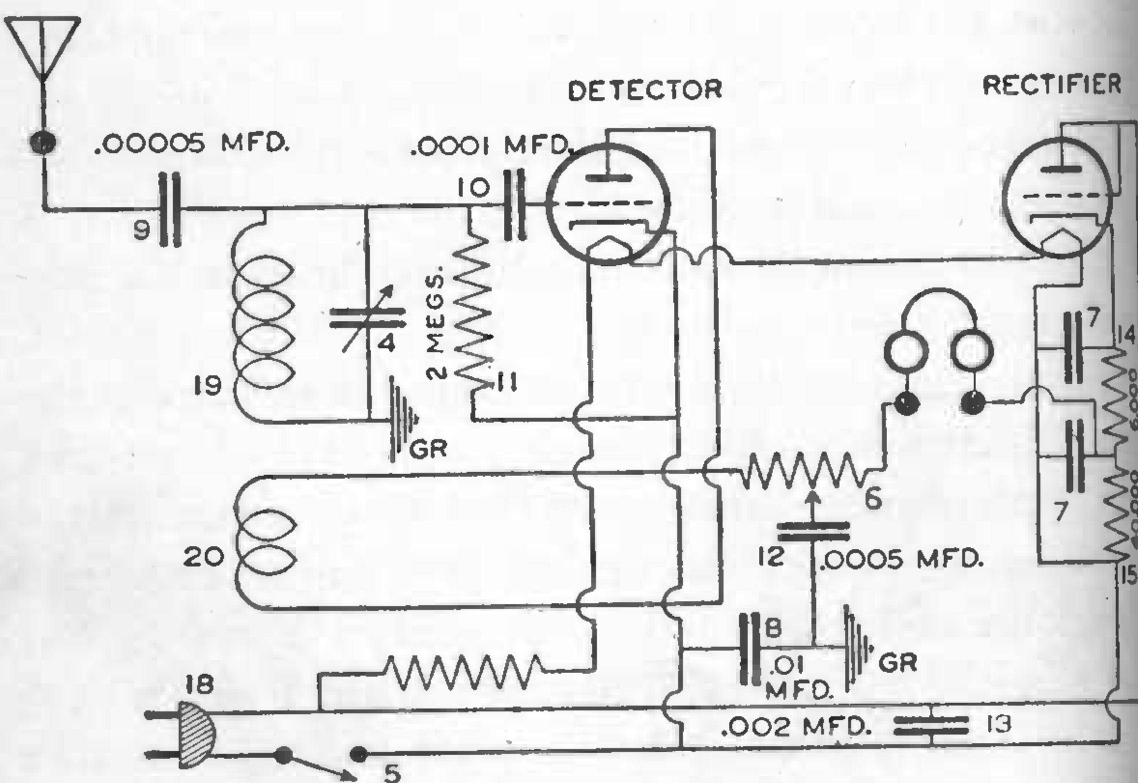
The line cord resistor (18) is tied to a screw-eye in the base near the front right-hand corner. This anchors the cord so that the terminals are relieved from strain. The cord which was used in building the original receiver from which these plans were made consisted of one black,

Rear view of the 2-tube A.C.–D.C. receiver with speaker.

one red, and one green-covered wire. The green and the black wire were connected together at the plug, but the green wire contained a resistance of 330 ohms.

The heaters of the two tubes are connected in series

2-TUBE A.C.-D.C.
REGENERATIVE RECEIVER



The ground connections (marked GR) are connections made to the metal sheet on the bottom of the base. Although the switch (5) which turns the filament current on and off is close to the resistor cord plug (18) in the diagram, it is actually part of the regeneration control (6).

and fed with current from the red and green wires in the line resistor cord. Thus the 330-ohm resistance in the line cord reduces the current to the proper value so that it will not burn out the heaters. The switch (5) is included in the circuit so that twisting the knob (16) turns the heater current on and off.

The double-section 8-8 Mfd. condenser should be fastened to the base with two screws. Notice that two of the terminal wires are red and one is black. Be certain to connect them as shown on the plan.

When all the connections have been made and checked, the receiver is ready for testing.

Place a No. 76 tube in sockets 2 and 3 and one of the broadcasting coils in socket 1.

Connect the antenna to the ANTENNA binding post and plug the line cord resistor into a 110-120-volt outlet. If it is an A.C. outlet it will not matter how you put the plug in, but if it is a D.C. outlet you may have to pull the plug out and put it back in with the plugs reversed before the current will flow through the receiver in the proper direction.

Connect a telephone receiver or a set of ear-phones to the PHONES binding posts. Turn the knob (16) so that the switch is closed and the tubes light. It will be a minute or so before the tubes are hot enough to operate.

Slip on the ear-phones and tune in a broadcast station by slowly turning the variable tuning condenser knob (17). Turn the potentiometer knob (16) to control the regenerative action of the detector. At first it is best to turn this until a distinct hiss is heard in the phones. When the variable condenser is rotated slowly, a series of whistles and squeals will be heard in the phones, each indicating a different broadcast station. The whistling can be cleared by a slight adjustment of the variable condenser and the regeneration control knob. Broadcast signals should then be heard. Weak signals necessitate a very careful and close adjustment of all the controls.

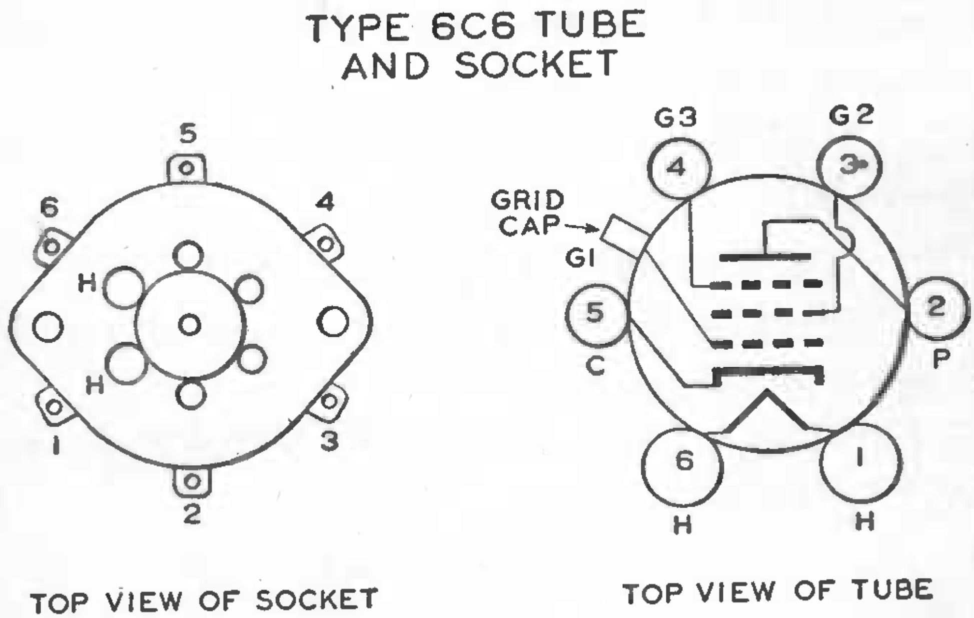
If the set has been properly wired, no trouble should be experienced in getting it into satisfactory operation. In the event that no squeals or signals are heard, recheck all connections. Make certain that both tubes are lighted.

If no squeals or whistles are heard in the phones when the tuning controls are rotated, it is an indication that the receiver is not regenerating. Sometimes failure of the receiver to regenerate is due to the tickler-coil winding being reversed. In that case it will be necessary to reverse the connections T and T on the coil socket (1). Do not make this change, however, until you are certain that failure of the receiver to regenerate is not due to any other cause.

CHAPTER IX

How to Build a 2-Tube A.C.-D.C. Receiver with Speaker

WHEN YOU look over the schematic circuit and the plan for this receiver, you will realize that it is somewhat more



Type 6C6 tube has six prongs and a grid cap. You will need a grid clip in order to make connection to the cap. The two prongs (HH) connected to the heater are larger than the others and serve to locate the tube in its socket. In the diagram above, the prongs are numbered to match the corresponding socket terminal to which they connect when the tube is inserted.

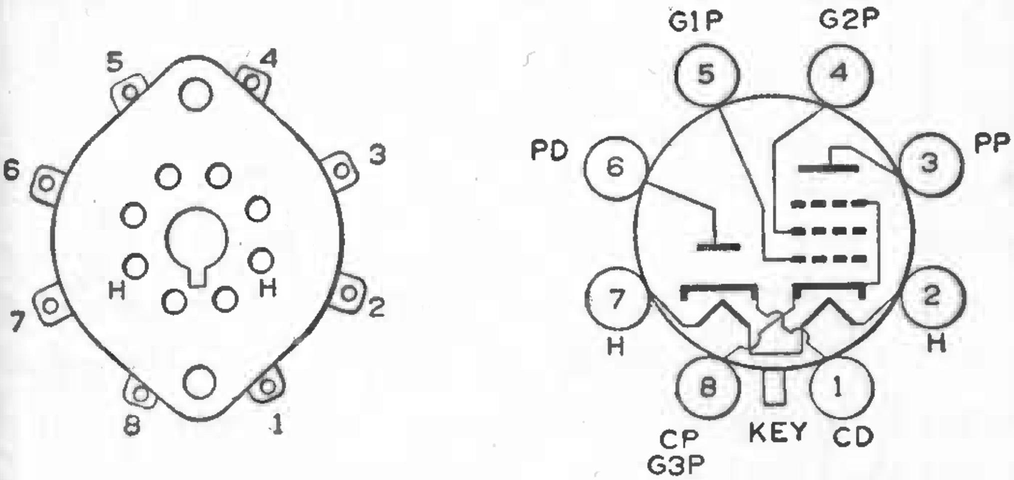
elaborate than the two-tube receiver described in the last chapter. The tubes make it so. It employs a type 6C6 and a 25A7-G. The type 6C6 is known to radio engineers as a triple-grid detector amplifier. It has six contact pins on the base and a grid cap on top. The 25A7-G is "two tubes in one." It is a rectifier-pentode, in radio language. The rectifier portion changes the 110-volt alternating current into rectified direct current. The pentode acts as a power amplifier. It is the amplifying action of the pentode which increases or strengthens the energy delivered by the detector so that it will operate a small speaker. The 25A7-G has eight contact pins on the base. Eight connections to the 25A7-G tube and seven to the 6C6 make the circuit seem complicated. It is in making these connections that the novice is most likely to make a mistake. But if you proceed slowly and carefully, consulting the plan and circuit diagrams and checking each wire before and after you put it in place, you will not have any trouble.

An antenna fifty feet long will give good reception for both near and distant stations.

The following parts are required for building a 2-tube A.C.-D.C. set with speaker:

1 Wood base 14¼" x 5¾" x ¾"
1 Plywood panel 14¼" x 5½" x ¼"
1 Piece of sheet metal 14" x 5"
1 Type 6C6 Tube
1 Type 25A7 Tube
1 5-prong socket
1 6-prong socket
1 8-prong socket
1 Set 5-prong plug-in coils
1 4-inch permanent magnet speaker
1 360 Mmfd. variable condenser

TYPE 25A7-G TUBE
AND SOCKET

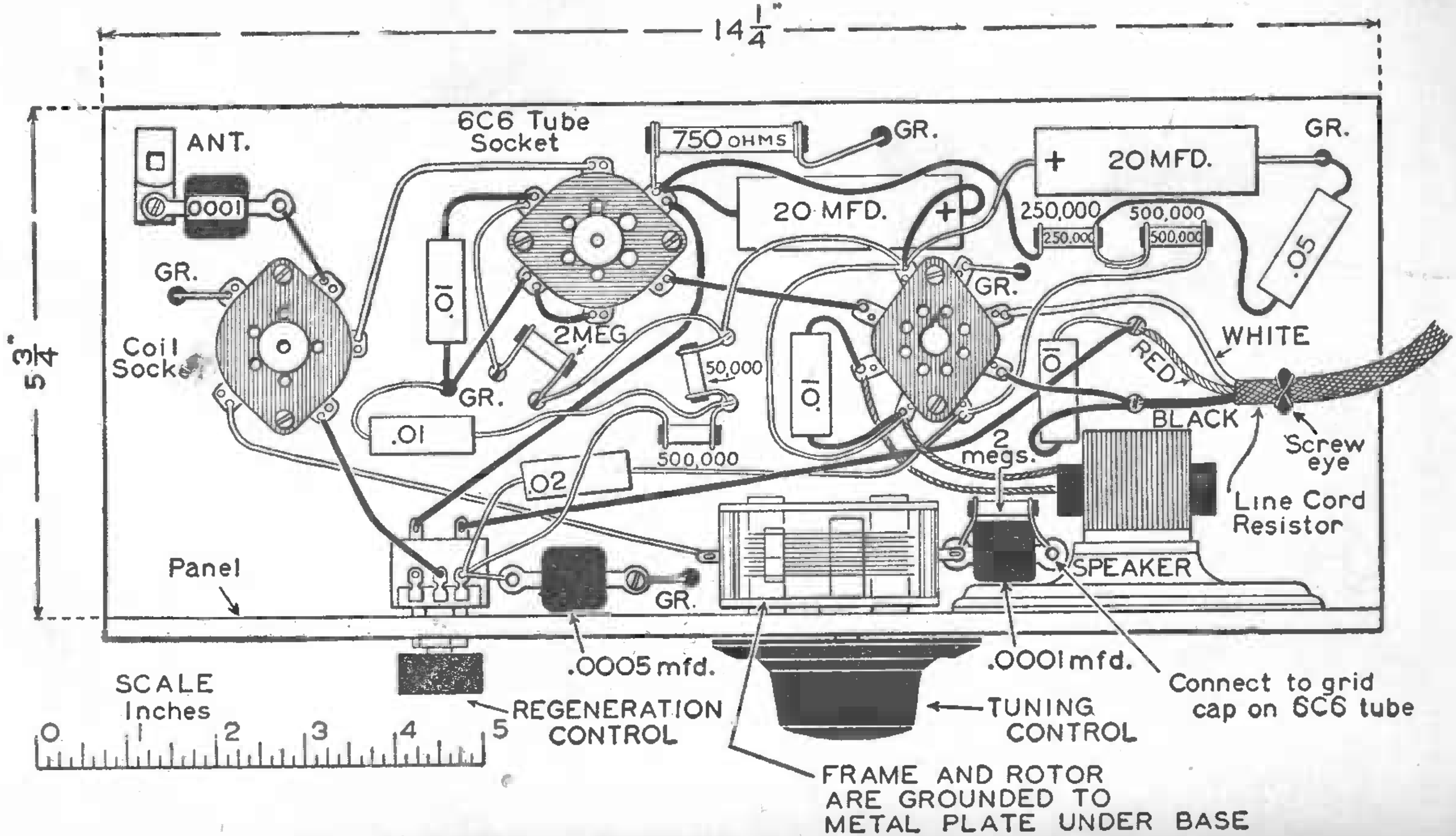


TOP VIEW OF SOCKET TOP VIEW OF TUBE

To the novice, the most confusing part of wiring a radio receiver is making the connections to the socket. It is, of course, absolutely necessary to make these correctly or the heaters, grids, plates, etc., in the tube will not be properly connected in the circuit. The diagram above will help when making connections to a type 25A7-G tube. The base of the tube has eight prongs, all of the same size. The prongs are located in the proper socket hole by a key on the base of the tube which fits into a slot in the socket. There are no identifying numbers or letters on tubes and sockets as shown in the diagram. In the illustration the prongs connected to the heater terminals and their holes in the socket are marked H. Also all prongs are numbered so as to correspond with the numbers alongside the socket terminals to which they connect.

1 10,000-ohm volume control with switch and knob
1 290-ohm line cord resistor
1 Vernier dial
4 .01 Mfd. tubular paper condensers
1 .05 Mfd. tubular paper condensers
1 .02 Mfd. tubular paper condensers
1 .0005 mica condensers
2 .0001 mica condensers
1 250,000-ohm ¼-watt resistor

PLAN OF 2-TUBE A.C-D.C. SET WITH SPEAKER



PLAN OF 2-TUBE A.C.-D.C. SET WITH SPEAKER

Use this plan in arranging the various parts of the receiver on the base and panel. Distances in inches can be determined with a pair of dividers and the scale at the lower left. Four mounting strips (not shown in the illustration) can be used to good advantage when wiring this receiver.

1 5-megohm ¼-watt resistor
2 500,000-ohm ¼-watt resistors
1 2-megohm ¼-watt resistor
1 750-ohm 1-watt resistor
1 50,000-ohm ¼-watt resistor
2 20-Mfd. 200-volt electrolytic condensers
1 Grid cap clip
1 Binding post
Screws, solder, push-back wire, etc.

The procedure in assembling and wiring the receiver is the same as that used for the receivers described in Chapter VIII. You will need a dry wooden base 14½" x 5¾" x ¾" and a plywood panel 14¼" x 5½" x ¼". Both should be shellacked or varnished. Whenever condensers, resistors, and other radio parts are mounted on a wooden base or panel, it is essential that the wood be dry. Damp or unseasoned wood is not an insulator. Shellacking or varnishing both surfaces and all edges of a base or panel will keep moisture out.

The plan shows the position of the various parts as they should be mounted on the base and panel. You can use the scale shown in the lower left-hand corner as a rule or measure to determine dimensions and distances. The regeneration control and switch (10,000-ohm volume control), the tuning control, and the speaker are mounted on the back of the panel. The speaker is mounted directly behind a circular hole 3⅝" in diameter cut in the panel so as to permit the sound waves to pass through. If the receiver is to be used to tune in broadcast stations only, an ordinary dial and knob fitted to the tuning condenser will be satisfactory. But if short waves are to be tuned in, the much more accurate adjustments of the tuning condenser then necessary make a vernier dial control advisable. It may be necessary to shorten both the condenser shaft and the regeneration control shaft before the knobs can be fitted properly.

Mounting strips (see page 131) can be used to good advantage to support some of the resistors and condensers. In place of mounting strips you can use small brass nails or brass screws driven into the base. The plan shows screws.

The end of the line cord resistor should be anchored by tying to a screw-eye in the base.

The 14″ x 5″ sheet metal may be brass, copper, tin, or galvanized iron. In fact, if you are skilful at soldering and can solder to iron and steel, one of these metals may be used. The metal sheet should be attached to the underside of the wooden base with small brads. A round-headed upholsterer's nail in each corner will raise the metal above the surface of a table or desk upon which the receiver may rest and protect the varnish from scratches. The purpose of the metal sheet is to provide a "ground" to which several of the condensers may be connected. The rotor of the variable tuning condenser is connected to this artificial ground to prevent what is termed "body capacity effect."

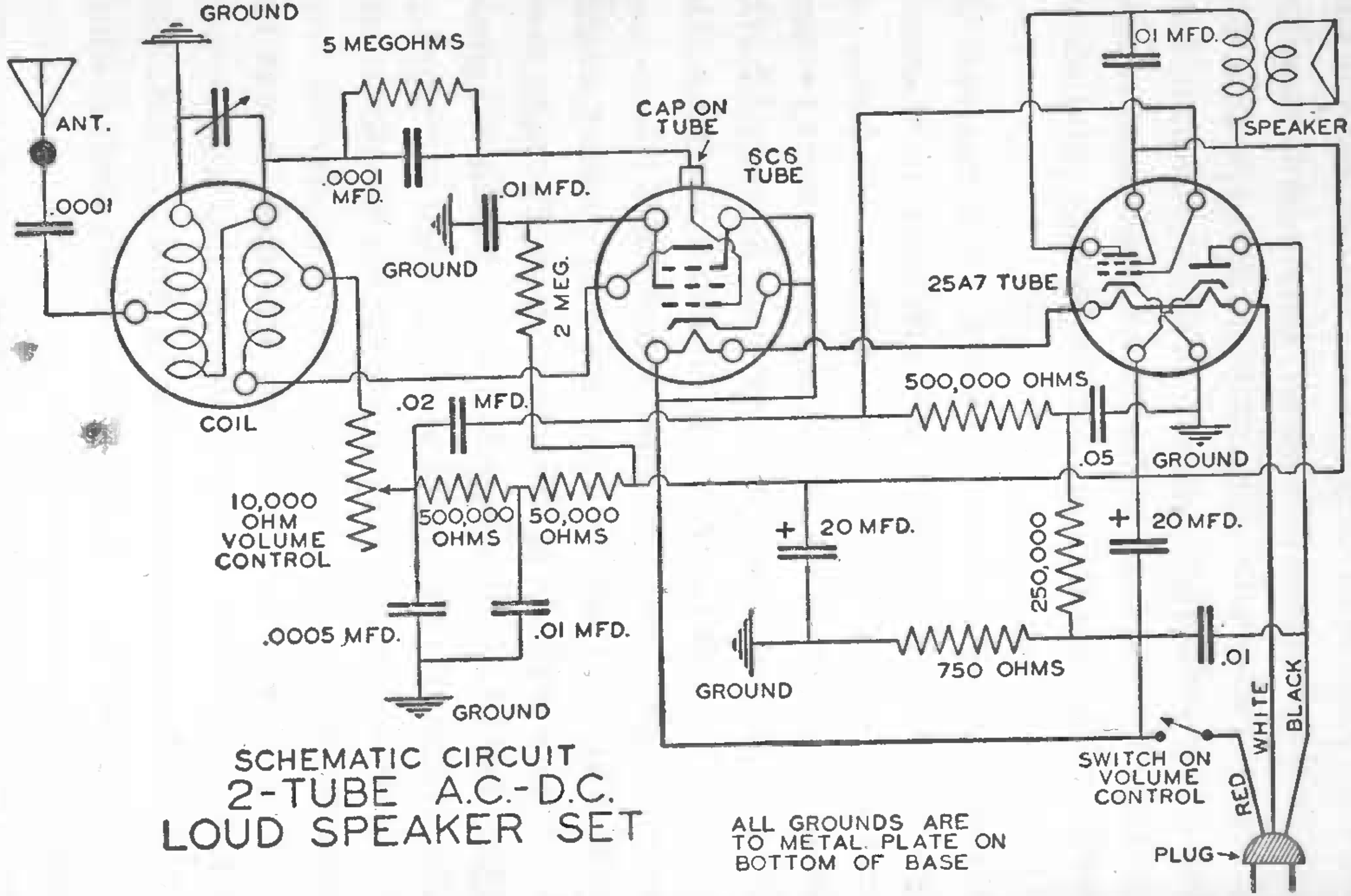
Without this, your hand, as it is moved to or from the tuning knob on the variable condenser, would have an effect on the tuning. Twenty-five years ago, when experimenters first began to use the regenerative detector, it was not unusual to tune the variable condenser with a hard rubber rod two feet long, so that the hands would produce no body effect.

If base-mounting sockets are used, they can rest directly on the base. If wafer sockets are used, they should be set on spacers which raise them up from the base.

When all the parts are in place, the set is ready for wiring. The connecting wires, as they were arranged in the original model of this receiver, are shown in the plan. The schematic circuit should also be consulted.

Here is a method which may make the wiring easier. Push-back wire is made in different colors. Procure some red, green, and black. Wire part of the set with red push-back wire. As you do this, trace or check each corresponding wire on the plan and schematic circuit diagram with a *red* pencil. Then wire another portion of the set with *green* and check or trace the corresponding wires in the illustrations with a *green* pencil. Finish the wiring with *black* wire and check or trace with a *black* pencil. This may make it easier to avoid mistakes and to avoid omitting any wires. Use rosin-core solder only.

The condensers shown to be "grounded" in the schematic circuit diagram have one terminal connected to the



SCHEMATIC CIRCUIT
2-TUBE A.C.-D.C.
LOUD SPEAKER SET

You will find this schematic circuit diagram as well as the plan useful when wiring the receiver. All the grounds are connections to the metal plate on the bottom of the wooden base.

metal sheet on the underside of the base. Drill a hole for each "ground" connection through the wooden base and through the sheet metal. Slip the wire into the hole and solder to the sheet metal.

The plug-in coils used with this receiver should have five prongs. They can be obtained from several radio firms which carry parts for amateurs.

When the wiring has been completed and checked, the receiver is ready to put into operation. Place a broadcast plug-in coil in the coil socket. Put a 6C6 and a 25A7-G tube into the proper sockets. Put the plug on the line cord resistor into a 110-volt outlet. If it is an A.C. outlet it will not matter how it is plugged in. If it is a D.C. outlet it may be necessary to take the plug out, turn it 180 degrees and put it back in so as to reverse the polarity of the current. Connect the antenna to the antenna binding post or connector. No ground is necessary, and no connection should be made to any grounded metal.

Do not set the receiver on a radiator or any other grounded object.

Switch on the set by turning the regeneration control in a clockwise direction. Wait for about thirty seconds for the tubes to heat up. Then turn the volume control more in a clockwise direction and rotate the tuning control until either music or speech or a whistling sound is heard. If a whistling is heard, turn the regeneration control counter-clockwise until it disappears and music or speech is heard.

CHAPTER X

Radio Licenses and Learning to Telegraph

No license or permit of any sort is needed in order to build, own, or operate a radio *receiver* in the United States of America. At least, this is true in time of peace. It may not be true at a time when the country is at war or threatened with war. Then orders issued by the President or by military authorities might command that all radio apparatus be dismantled.

Any of the apparatus described in this book can be built or operated without permit or license.

A LICENSE IS REQUIRED FOR A RADIO TRANSMITTER

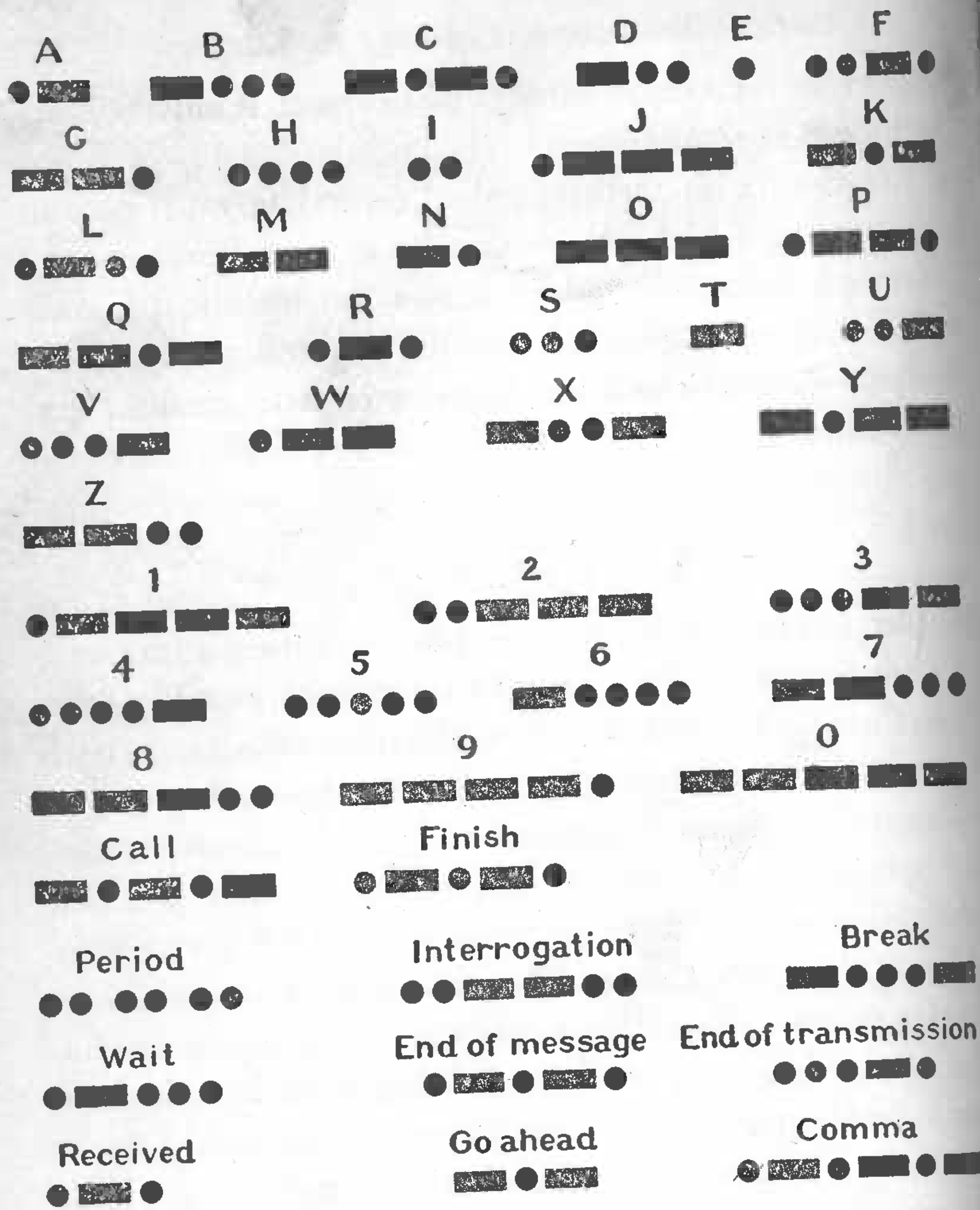
The *transmission* of radio messages is controlled by federal laws, and both the operator of transmitting apparatus and the transmitter itself must be licensed. This is necessary. It is possible for two radio stations which are sending messages at the same time to interfere or "jam," as it is called among radio operators. Without the existing radio laws and the regulations of the Federal Communications Commission, intelligible radio reception would be impossible much of the time.

In order for a transmitter to be licensed, it must comply with certain requirements.

In order for an operator to be licensed, he must pass an examination which proves that he can send and receive telegraph messages and possesses the technical knowledge required to operate a transmitter intelligently. There are two general classes of licenses issued: amateur and professional.

WHAT IS A RADIO AMATEUR?

Licenses for transmitters and for operating a transmitter are issued by the Federal Communications Commission through Radio Inspectors who have offices in various parts of the country at convenient locations. Any person —age or sex places no limitations—who has been licensed to operate a *non-commercial* radio-transmitter is a full-fledged *amateur*. There are more than 50,000 active amateurs in the United States. They comprise boys, girls, men, and women. Many thousands of the members of this group communicate with each other both by telegraph code and by radiophone over all parts of the world. Some "hams" or amateur operators have licenses for portable transmitters installed in automobiles or aboard motorboats. From the ranks of the amateurs have come most of our radio manufacturers, engineers, and inventors. During the World War, the radio operators of the United



THE CONTINENTAL CODE

The Continental code or alphabet is used in radio telegraphy. The first step in learning to telegraph is to memorize the alphabet so that each character can be instantly called to mind at will. Think of a dot as the sound *dit* and of a dash as *dah*. This is a close imitation of the actual sounds of the dots and dashes when they are heard in a receiver.

States Army and Navy were the most skilful. The best of them were ex-amateurs.

LEARN TO TELEGRAPH

Radio telegraph messages are transmitted in the dot and dash language of the Continental telegraph code. With the exception of a few characters, this is the same as the American Morse code used in sending telegraph messages over land lines. The Continental code is simpler than Morse. Morse uses spaces in addition to dots and dashes. There are no spaces in the characters of the Continental code.

You will enjoy your radio more if you learn to telegraph. Not only can you tune in and listen to amateurs, ships, and shore stations, but you can probably obtain a license to operate a transmitter of your own.

THE REQUIREMENTS FOR AN AMATEUR LICENSE

No fee is required for a radio license. It is necessary merely to pass a simple examination in elementary radio theory, in the Federal Radio Regulations, and in sending and receiving the Continental telegraph code.

You can acquire a knowledge of elementary radio theory by reading radio books and magazines. Building your own receivers will help. For twenty-five cents you can purchase a pamphlet which contains all the questions that are asked in the examinations for an amateur radio license, as well as the answers thereto.

When you can send and receive sixty-five letters, numerals, and punctuation-marks per minute accurately, you can pass the government code test for an amateur license. This is not difficult. It merely requires practice.

Examinations are given at several offices of the Federal Communications Commission. If it is not convenient to go to one of these offices, you may arrange to take an examination for a Class C amateur license under the supervision of a licensed operator in your own home town.

During an examination, the code test is given first. If the applicant passes this, he is permitted to proceed with the written part of the examination covering technical problems and the radio laws. The sending and receiving tests are both five minutes in length. If sixty-five consecutive characters are copied correctly somewhere during the first five-minute period, the applicant may then try his hand at transmitting. If sixty-five consecutive characters are sent correctly in one minute sometime during the five-minute test, a passing mark is awarded, and the applicant proceeds to write the answers to a set of questions.

FAILURE TO PASS THE CODE TEST

When an applicant fails to pass the code test, he can try again three months later; during the interval he can practise and improve his skill at the code.

LEARNING TO TELEGRAPH

The first step in learning to telegraph is to memorize the code so that the sound of each character can be called to mind instantly. In memorizing the code, do not think of the characters as dots and dashes as they are

SOUND CODE

A	Ditdah	J	Ditdahdahdah	S	Ditditdit
B	Dahditditdit	K	Dahditdah	T	Dah
C	Dahditdahdit	L	Ditdahditdit	U	Ditditdah
D	Dahditdit	M	Dahdah	V	Ditditditdah
E	Dit	N	Dahdit	W	Ditdahdah
F	Ditditdahdit	O	Dahdahdah	X	Dahditditdah
G	Dahdahdit	P	Ditdahdahdit	Y	Dahditdahdah
H	Ditditditdit	Q	Dahdahditdah	Z	Dahdahditdit
I	Ditdit	R	Ditdahdit		

Here are the letters of the radio alphabet as they sound when heard in the head-phones. Many experts believe that the best procedure is to memorize the code as the sounds *dit* and *dah* and not as dots and dashes. A *dit* represents a dot and a *dah* is a dash under this system.

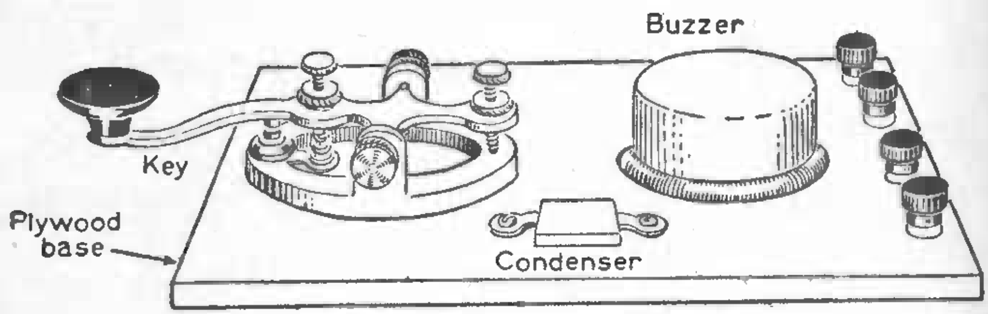
ordinarily represented on paper but rather as sounds in which a dot represents the sound *dit* and a dash represents the sound *dah*. For example, it is better to think of A as the sound *dit-dah* and not as a dot and dash.

When all the letters of the code have been memorized, practise reading signs, pages from books, etc., aloud in "dit-dah" language.

BUZZER PRACTICE SETS

It will help to learn to receive code, if you practise sending at the same time. The simplest way to do this

Buzzer Code Practice Set



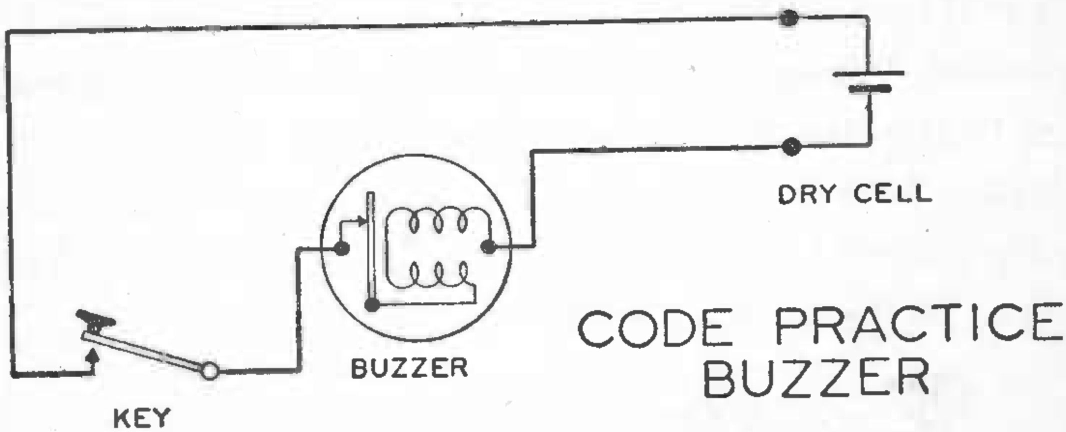
Buzzer practice sets should be mounted on a thin base (¼" plywood) so as to keep the key knob as close to the table top as possible. The wiring diagram for connecting this set is shown on page 161.

is to connect a telegraph key in series with a small buzzer and a battery so that by pressing the key you can make *dit* and *dah* sounds on the buzzer. A *dah* should be three times as long as a *dit*.

An ordinary call buzzer can be used. But one of the small high frequency buzzers made especially for code practice will produce a sound exactly like a radio signal.

There are several methods of arranging code practice sets which will give a fairly good imitation of radio signals.

By adding a .001 Mfd. fixed condenser and a pair of head-phones to a key, buzzer, and battery set, the buzzer



A telegraph key connected in series with a dry cell and a small buzzer may be used for code practice. This arrangement may also be used as a test buzzer to adjust crystal detectors. It will operate best as a test buzzer if one terminal of the buzzer is grounded.

signals can be heard in the phones. More than one pair of head-phones can be used at the same time by connecting them in multiple as shown in the illustration. If the signals in the phones are too loud, they may be reduced by using a condenser of smaller capacity.

The best way to learn to send and receive is under the tutelage of an experienced operator.

The best substitute for a teacher is for two beginners to practise together by sending messages to each other with a code practice set.

A very good method of arranging a code practice set is to connect a buzzer, battery, and switch so that the buzzer operates continuously when the switch is closed. This tends to keep the tone of the buzzer at a steadier pitch. A pair of head-phones and a key are connected across the terminals of the buzzer's electro-magnets. Signals will be heard in the head-phones only when the key is pressed. When practice is finished, the switch is opened so as to stop the buzzer and conserve the battery.

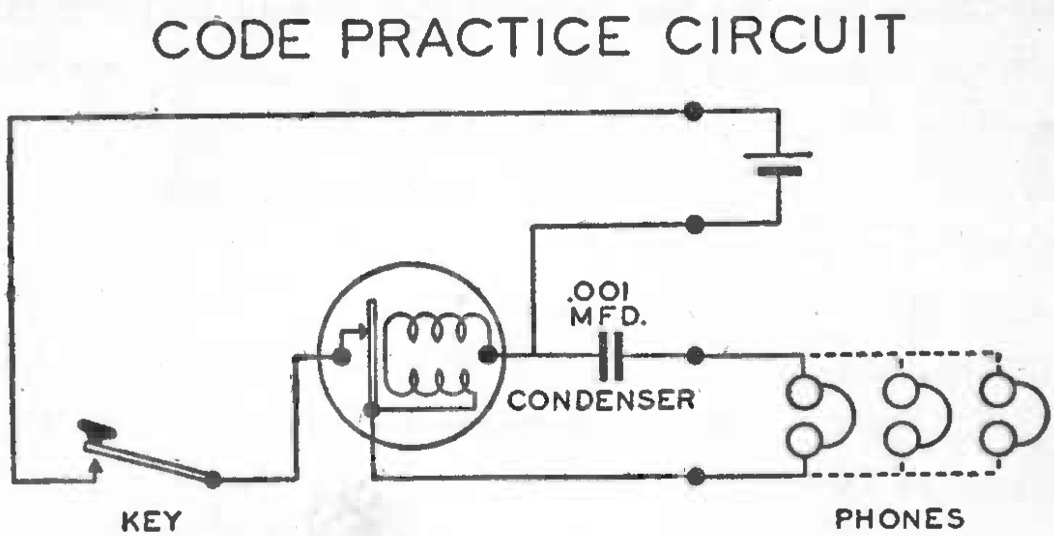
Buzzer practice sets should be mounted on a thin base (¼″ plywood) so as to keep the level of the key knob as close to the table as possible.

CODE PRACTICE

A large part of the "trick" of becoming a good telegraph operator is to form good habits in the beginning.

Proper adjustment of a telegraph key is important. The spring tension and the motion of the key lever must be adjusted so that the key has the "right feeling." The tendency of the beginner is to "open" the key (separate the contact points) too far. Then the key lever has too much movement and signals sent with it will be "choppy." The key contacts should be adjusted so that the space between is not more than 1/16″. On the other hand, if the points are too close together, the sending will be "sloppy." The tension of the spring which pushes the lever up should be adjusted so that it is quite light.

If possible, have your key adjusted by an experienced amateur or telegraph operator; tighten the lock-nuts on



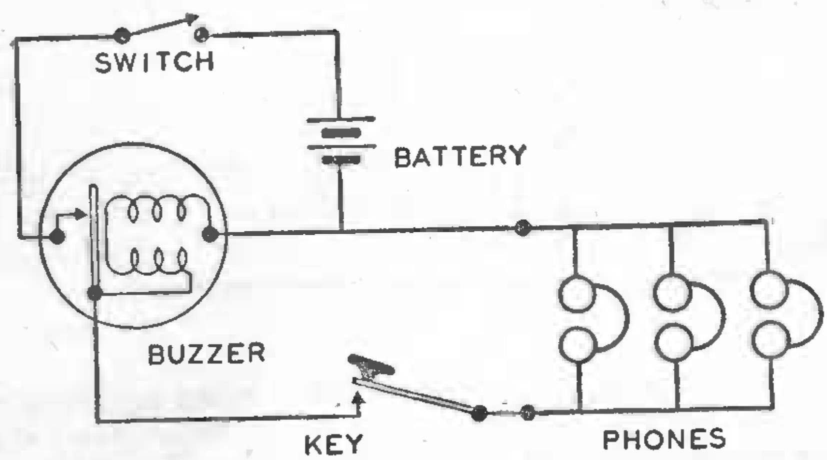
By adding a .001 Mfd. fixed condenser to the key and buzzer, imitation radio signals can be produced in a pair of head-phones. More than one pair of head-phones can be used at the same time by connecting them as shown in the illustration. Should a .001 Mfd. condenser produce excessively loud signals in the phones, a smaller condenser, perhaps .00025 Mfd. should be used.

the adjusting screws, and then do not change the adjustment.

A telegraph key should be firmly fastened to a board or to a table. When a skilled operator grasps the key knob, his forearm rests on the table. He holds the key knob gently with his thumb slightly under the edge of the knob, and his first and second fingers on top of the knob or slightly over the edge.

Remember to relax. Do not "pull the knob off the key lever." Handle it gently. Every beginner makes the mistake of trying to send too rapidly. Seek accuracy first, speed will come later. When you have mastered the code, you can improve your speed. Send slowly and carefully,

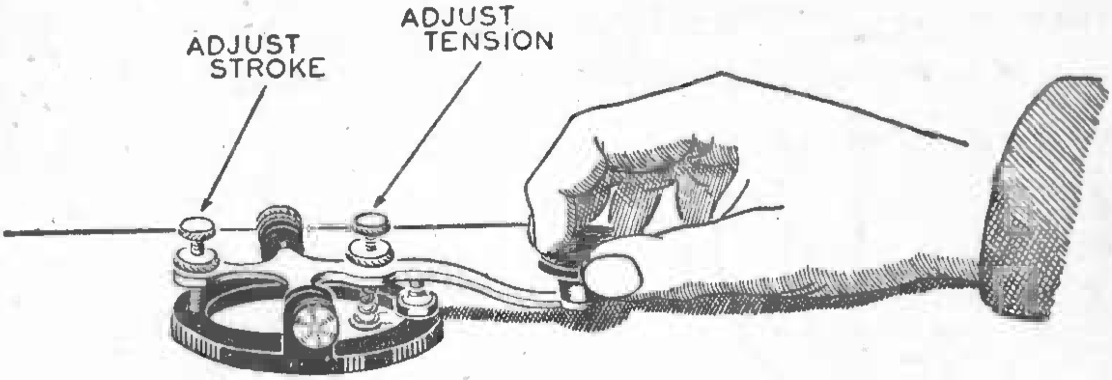
CODE PRACTICE SET



Another method of arranging a code practice set is to connect a buzzer, battery and switch so that the buzzer operates continuously when the switch is closed, as shown in the circuit diagram above. This tends to keep the buzzer at a steadier pitch. Signals can be heard in the phones, only when the key is pressed. The key and phones are connected across the terminals of the buzzer's electromagnets.

not any faster than you can receive. A *dit* sound is made by pressing the key down and letting it come up again just as soon as possible. The *dah* sound is made by pressing the key down and holding it down for an instant so that the *dah* sound is three times as long as the *dit* sound.

The letter L is a short *dah*. E is *dit*, and zero is a long *dah*. All the other letters and numerals are combinations of two or more *dit* and *dah* sounds.



THE CORRECT POSITION OF THE HAND AND FINGERS

The correct way to grasp the key knob is important. The thumb should be against the left side of the knob. The first and second fingers should be bent a little and rest partly on top and partly over the edge of the knob. The arm should rest lightly on the table with the wrist held above the table. Do not use the whole arm in sending. It is done with a wrist motion.

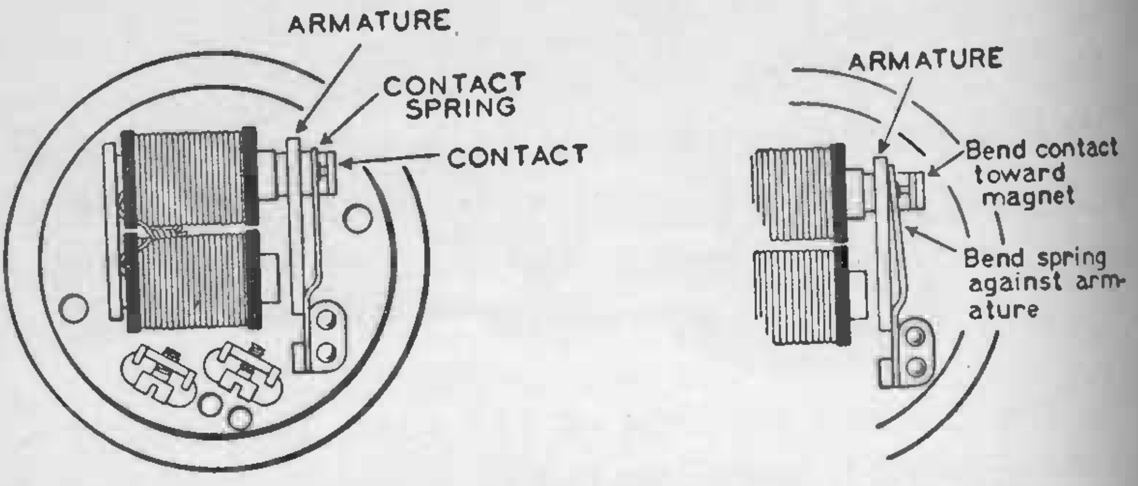
THE SOUND OF THE LETTERS

The *dits* and *dahs* which form a single letter, numeral, or punctuation-mark should roll into one another with no pause between. For example, the letter A should not be made so that it sounds like *dit dah* and the letter B like *dah dit dit dit.* They should sound like this: A—*ditdah;* B—*dahditditdit.*

Pause slightly between letters, making the interval about equal to the time that it takes to make a *dah.* Make the interval between words equivalent to five *dits* or two *dahs.*

LEARNING TO READ TELEGRAPH MESSAGES

A practical method of learning to read radio telegraph



HOW TO RAISE THE PITCH OF A SMALL BUZZER

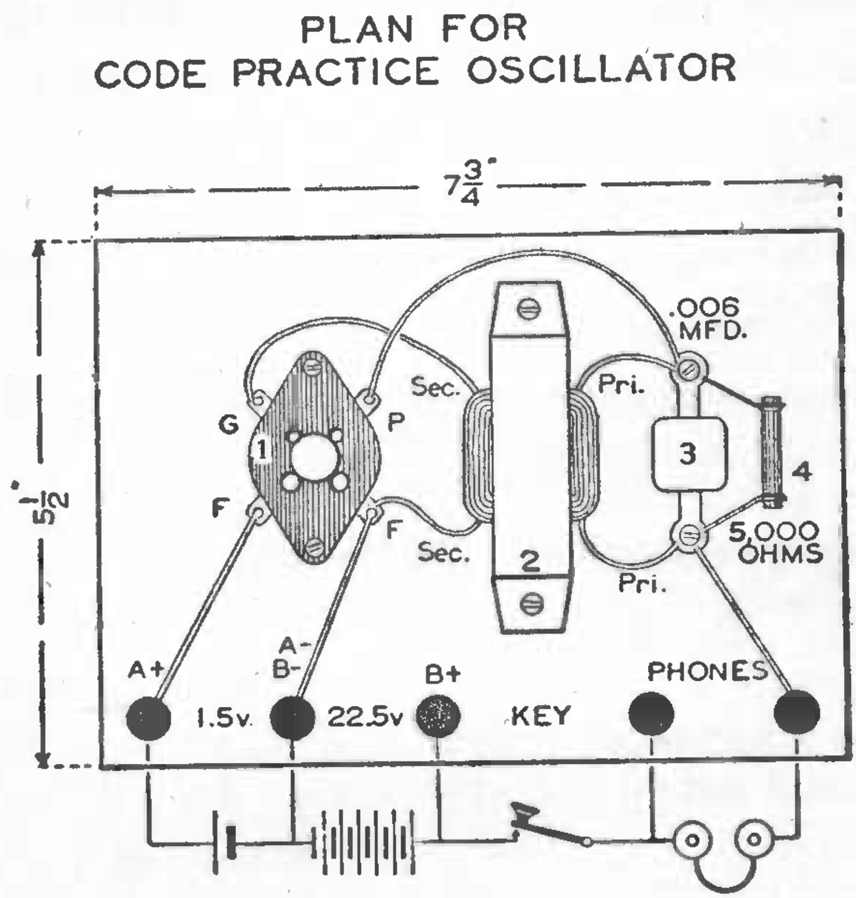
The pitch of a small call buzzer is lower than the pitch of radiotelegraph signals. In order to give a better imitation of radio signals the note of the buzzer can be raised somewhat by a slight adjustment. Bend the contact spring attached to the armature until the end of the spring carrying the contact remains pressed against the armature. Bend the small bracket carrying the fixed contact toward the armature slightly so as to shorten the distance the armature moves back and forth in its vibration.

messages is to work with one letter at a time. For example, pick the letter O. Repeating its sound, *dahdahdah,* to yourself, tune in on a short-wave receiver until a slow-sending amateur code transmitter is heard.

Listen for *dahdahdah* and each time it is heard, write the letter O on a piece of paper. When you are certain that you can "copy" the letter O every time that you hear it, memorize the sound of another letter used frequently, and repeat the process of picking it out of some slow code transmission. Before long, you will be able to copy words, and whole messages soon after. Speed will come gradually with practice.

A VACUUM TUBE CODE OSCILLATOR

It is a simple matter to build a vacuum tube code practice set which will prove to be more desirable than any of the buzzer devices described elsewhere in this



A code practice oscillator gives more stable tones than a buzzer. It is silent, its signals can be heard only in the head-phones. The oscillator consists of a No. 30 radio tube which fits into a socket (1) and is connected to an audio-frequency amplifying transformer (2); a .006 Mfd. condenser (3) and a 5,000-ohm, 2-watt resistor (4).

chapter. It emits a more stable tone than a buzzer and gives good signals in the phones without making any noise in the room.

A vacuum tube code practice oscillator is like a one-stage audio-frequency amplifier in appearance. It consists of a vacuum tube, audio-frequency transformer, condenser, resistor, telegraph key, head-phones, and batteries. The vacuum tube acts as an oscillator or generator of alternating currents. It is these currents which produce the tone heard in the phones. The pitch of the sound can be varied by merely increasing or decreasing the B battery voltage.

The following parts are needed for a vacuum tube code oscillator:

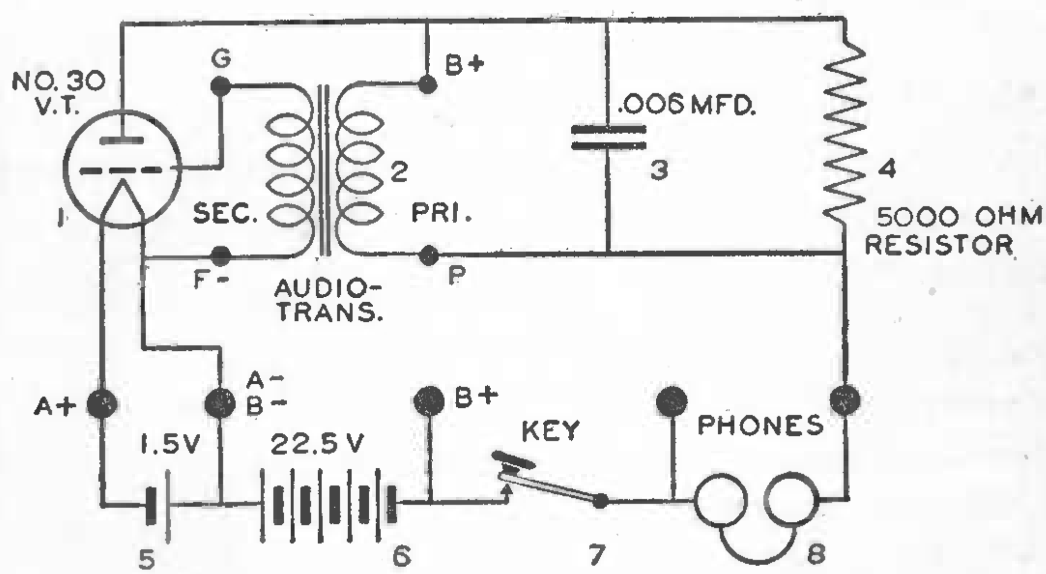
1 Wood base, 7¾" x 5½" x ¾"
1 No. 30 vacuum tube
1 4-prong socket
1 Audio-frequency amplifying transformer
1 5,000-ohm 2-watt resistor
1 .006 Mfd. paper-type condenser
5 Binding posts
1 1½-volt A battery
1 22½-volt B battery
1 Telegraph key
1 Pair head-phones

The audio-frequency transformer can be of any of the commonly used ratios, that is, from 2½ to 1 up to 3½ to 1.

The wood base should be shellacked or varnished and the parts mounted as shown in the plan. Use push-back wire and rosin-core solder to make the connections. The wiring is simple. Consult both the plan and the circuit diagram, and you will have no difficulty.

Connect a 1½-volt dry cell (No. 6) to the A binding

SCHEMATIC CIRCUIT
CODE PRACTICE OSCILLATOR



The No. 30 radio tube acts as a generator of alternating currents and can be adjusted to give a faithful imitation of radiotelegraph signals. The pitch of the sound can be varied by merely increasing or decreasing the B battery voltage. Use a 1½-volt dry cell to light the filament of the tube and a 22½- to 45-volt B battery to supply current to the plate circuit of the tube. The numerals 1 to 8 which appear on the diagram correspond to those shown on the plan and may be used to identify the various parts.

posts, a 22.5-volt B battery to the B binding posts, and a key and head-phones as shown in the diagrams. Be certain that the positive and negative terminals of the batteries are connected to the proper binding posts. Place a No. 30 tube in the socket. Give the filament a few seconds to warm up, and then press the key. A shrill note like that made by radio telegraph signals will be heard. When the code oscillator is not in use, disconnect the A battery or remove the tube from the socket.

CHAPTER XI

How to Build a Phonograph Oscillator and Use a Radio Receiver as an Electric Phonograph

ANY RADIO receiver which is provided with an amplifier and a speaker can be used as an electric phonograph. It is not necessary to make any alterations on the receiver. A phonograph turn-table and a suitably mounted phonograph pickup are needed to play the records. The turn-table may be driven by the old-fashioned mechanical spring type motor or by one of the modern electric phonograph motors. The important thing is for the turn-table to revolve at the proper speed. The common disk record is designed to be rotated at a rate of seventy-eight revolutions per minute.

HOW AN ELECTRIC PHONOGRAPH OPERATES

As you may already know, phonograph records are usually made by pressing sound vibrations into a disk of shellac composition. On the disk is a continuous spiral groove in which the needle of the phonograph reproducer or "sound box" runs while the record revolves. The groove has little horizontal wiggles whose wave-form corresponds to that of the original sounds impressed upon the record. You can see these "wiggles" if you examine the surface of a phonograph disc with the aid of a magnifying glass. Some are visible to the naked eye. When the needle of the reproducer is placed in the groove and the record is revolving at the proper speed, the needle is forced to move back and forth sideways as it follows the wiggles in the groove. If the needle is attached to an old-fashioned reproducer, its movements cause a mica diaphragm to vibrate and reproduce the original sounds from which the record was made. But if the needle is set in a modern pickup, its movements produce not sounds but tiny electrical currents corresponding to the original sounds from which the record was made.

Modern electric phonographs, developed during the last decade, are much superior to the old-fashioned sort. They consist of an electrically driven turn-table, a pickup and an amplifier and speaker.

Pickups operating on several different principles have been developed, but those now used are usually either *crystal* or *magnetic* pickups. The crystal pickup is probably the most satisfactory.

If the tiny currents, generated in a phonograph pickup by the motions of its needle in following the groove on a record, are sent into an amplifier connected to a speaker, sounds are reproduced. The speech and music from an electric phonograph of this sort is of much better quality and more faithful to the original than the music and speech of the old-fashioned acoustic phonograph.

HOW TO CONNECT A PHONOGRAPH PICKUP TO A RADIO RECEIVER

Electric phonograph motors fitted with a turn-table range in price from $2.00 to $20.00. Pickups vary in cost from $3.00 to $15.00. A complete electrically driven record player may be purchased for as little as $6.50.

Either a home-made or a commercial record player may be connected to any A.C. broadcast receiver equipped with a speaker. Many modern radio receivers are provided with two terminals or binding posts marked "Phono." To use one of these radios as a phonograph it is necessary merely to connect two wires from the pickup on the record player to the "Phono" posts.

When no terminals for a phonograph connection are provided, one wire from the pickup should be connected to the metal chassis of the receiver. If it is a set using screen grid cap tubes such as types 6J7, 6R7 or 6F5, remove the grid cap from the first audio amplifier tube and connect the other wire from the pickup to the cap on the tube. If you do not know which is the first audio amplifier tube in the receiver, a radio serviceman can inform you, if you give him the name of the maker and the model.

There are phono-adapters on the market which make connecting a pickup to a radio receiver quite simple. Some of these are a combination plug and receptacle which is placed in the proper tube socket and the tube then placed in the adapter. A switch, connected to the adapter, enables the receiver to be operated in normal manner as a radio receiver or as an electric phonograph without connecting and disconnecting any wires.

WIRED AND WIRELESS RECORD PLAYERS

There are two kinds of record players on the market. One is called a *wired* player and the other a *wireless* player. A wired player must be connected to a radio receiver by means of wires. A wireless player plays records through any radio set without any connecting wires to the receiver. It operates like a miniature radio transmitter and may be operated usually at a distance of 30–50 feet from the radio. The "secret" of the wireless player is an *oscillator*.

HOW TO BUILD A PHONOGRAPH OSCILLATOR

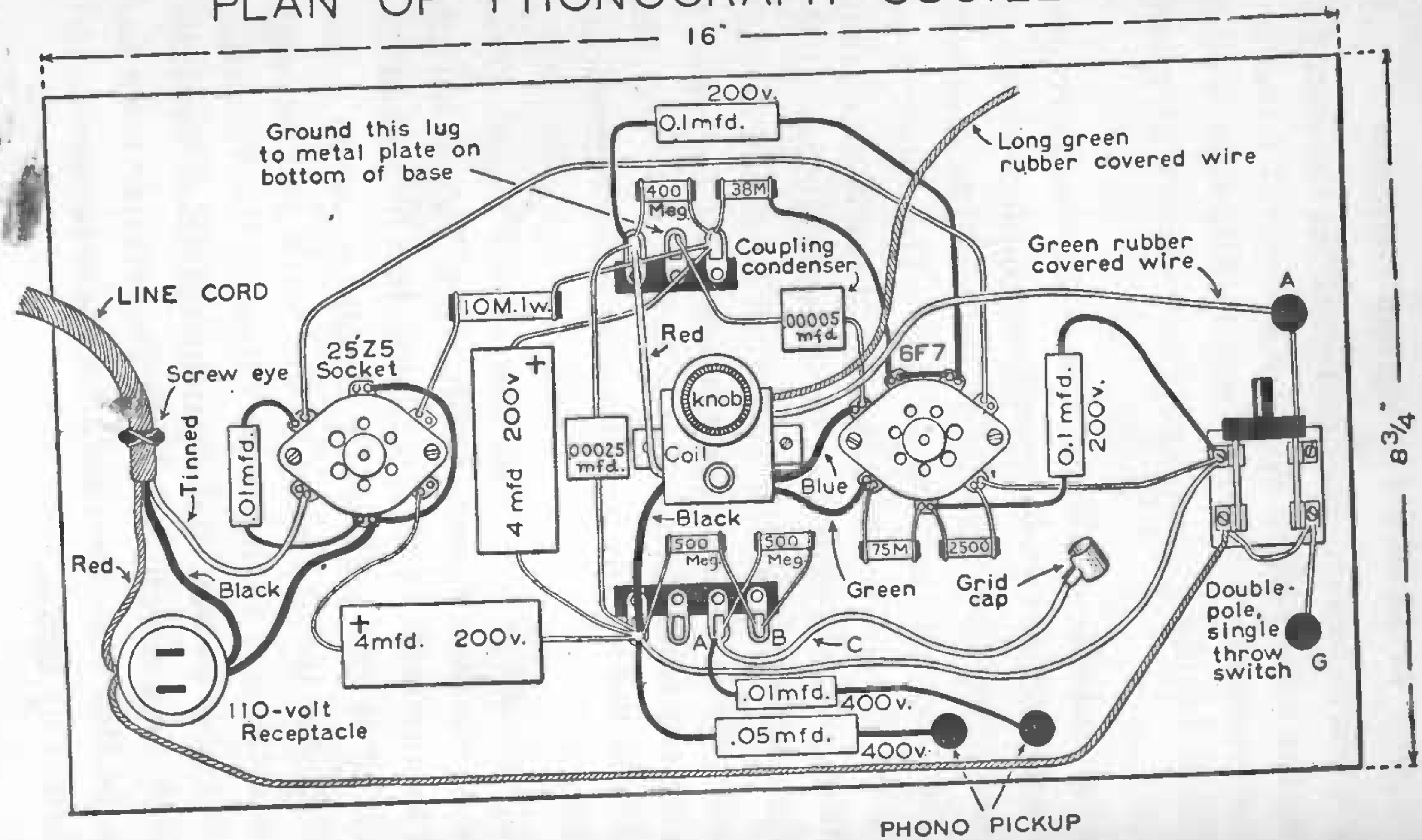
A phonograph oscillator can be built quickly and easily. The parts are inexpensive. There is nothing to make except the wooden base, a metal plate, and a small bracket. The parts are standard condensers, resistors, etc. The total cost including tubes will not be over $4.50.

The phonograph oscillator is a radio transmitter of very low power which radiates signals in the broadcast band that can be picked up by a broadcast receiver of sufficient sensitivity within twenty to fifty feet. Federal laws forbid building phonograph oscillators of greater power.

By means of this oscillator almost any radio receiver can be operated as an electric phonograph without any wires connecting the oscillator to the receiver and without in any way altering the receiver. The receiver can still be used to receive radio signals in the normal manner. The turn-table and the oscillator may be in the same room with the radio receiver, or in different parts of the same house. The radio receiver must be tuned to pick up signals from the oscillator in the same way that it would be if the signals were coming from a broadcasting station.

It happens sometimes that the useful range of an oscillator is less than twenty to fifty feet. This is usually due, not to any fault of the oscillator, but to a radio receiver which is not sufficiently sensitive, or to pipes, metal laths, and metal beams in the walls and ceilings. These materials are found more often in the construction of modern houses and apartments than in older homes. They may effectively shield the receiver from the oscillator. In that case the oscillator must be connected to the receiver by two wires.

PLAN OF PHONOGRAPH OSCILLATOR



Use this plan in arranging the parts of the oscillator on the base. Each resistor and condenser have been marked on the plan to show resistance and capacity. The abbreviations "Meg" and "M" stand for megohm. "W" stands for watt.

The following parts and materials are required for building the phonograph oscillator:

1 Wood base, 16" x 8¾"
1 Piece sheet metal 14" x 8"
1 No. 17–9373 phonograph oscillator coil
1 Type 6F7 triode-pentode tube
1 Type 25Z5 rectifier-doubler tube
1 7-prong socket for type 6F7 tube
1 6-prong socket for type 25Z5 tube
1 290-ohm line cord resistor
2 4 Mfd. 200-volt tubular electrolytic condensers
1 .00005 Mfd. mica condenser
1 .00025 Mfd. mica condenser
2 0.1 Mfd. 200-volt tubular condensers
2 .01 Mfd. 400-volt tubular condensers
1 10-megohm 1-watt resistor
1 75-megohm resistor
2 500-megohm resistor
1 400-megohm resistor
1 38-megohm resistor
1 2500-ohm resistor
1 4-lug mounting strip
1 3-lug mounting strip
4 Binding posts
1 Double-pole, single throw switch

All of the above parts, with the exception of the base and piece of sheet metal, are standard radio parts obtainable from dealers who carry supplies for amateurs.

ASSEMBLING THE OSCILLATOR

The first step toward assembling the oscillator is to make the wooden base. A piece of smooth white pine 16″ x 8¾″ x ¾″ makes a good base. You can use a smaller base if you wish and crowd the parts more closely together than is shown in the plan. It should be thoroughly dry and shellacked or varnished on sides, ends, top, and bottom so as to make it moisture-proof. The metal sheet is then attached to the underside with several small nails. Use a round-headed upholsterer's nail at each corner. These will raise the base up so that the metal sheet will not scratch any furniture that it may rest upon. The sheet is 14″ x 8″, not quite as large as the wooden base. It may be thin galvanized iron, sheet tin, brass, or copper. You can get a piece at a plumbing shop or tinsmith's or perhaps cut it from an old one-gallon can.

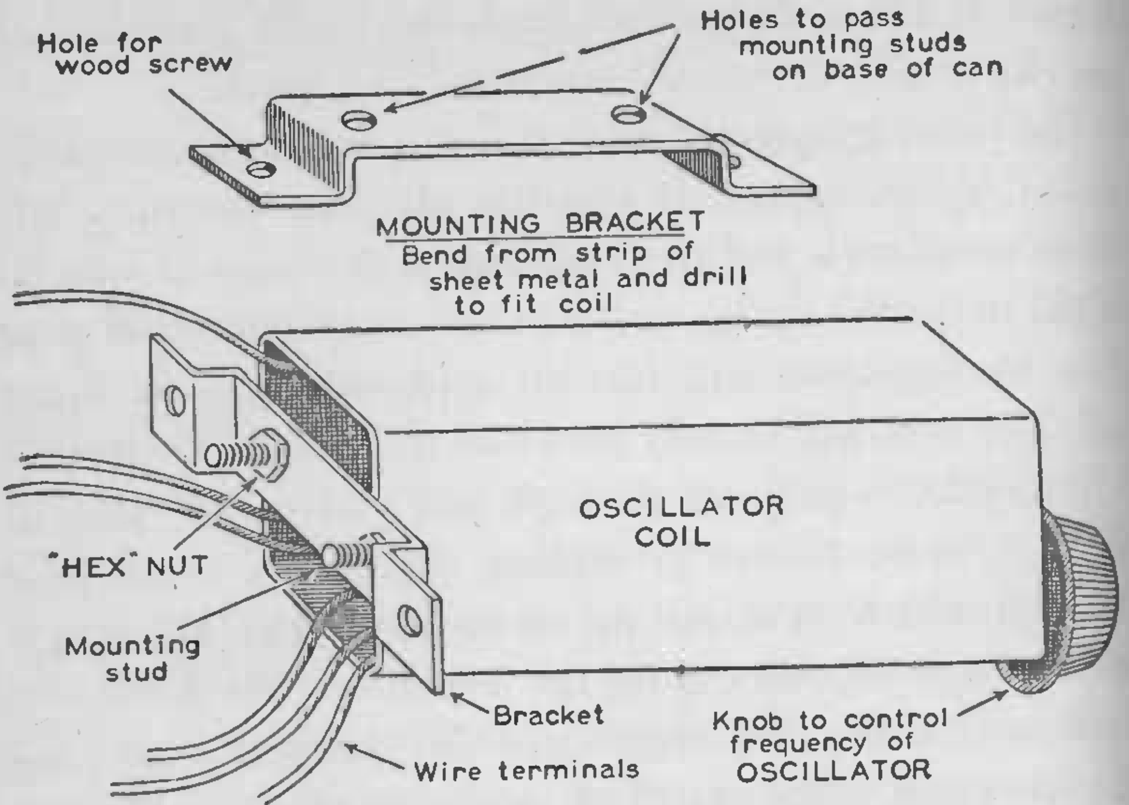
This metal sheet must not be grounded by setting the oscillator on anything connected with the ground. The signals from the oscillator radiate from this plate. The "ground" connection indicated in the schematic circuit and the plan is the metal plate.

The parts which compose the oscillator are mounted on the top of the base in the relative positions shown in the plan. Be certain to place the tube socket so that the two *large* holes into which the filament or heater prongs slip are in the same position as shown in the plan. Either base-mounting or wafer sockets may be used.

The phonograph oscillator coil can not be home-made except by an expert. It consists of three carefully adjusted small coils and two condensers enclosed in a metal shield or "can." Radio dealers who carry parts and supplies for amateurs can furnish a phonograph oscillator coil. The cost will usually be $1.25 to $2.00. A shaft with a tuning knob projects through one end of the can. In the top, close to the projecting shaft, is a small hole through which an adjusting screw is visible. The screw is the rough adjustment on the oscillator. The knob and shaft control the fine adjustment. Six wires emerge from the open end of the can. The mounting studs on the can were designed for a metal chassis, and in order to mount the coil on a wooden base, it is necessary to make a mounting strip from a piece of sheet metal as shown in the accompanying illustration. The mounting strip should be slipped over the studs on the can and fastened with two "hex" nuts. The strip is then secured to the wooden base by two wood screws so that the coil is in an upright position with the adjusting knob on top.

WIRING THE OSCILLATOR

The oscillator coil, sockets, lug mounting strips, switch, power receptacle, and binding posts should all be fas-



PHONOGRAPH OSCILLATOR COIL

It will be necessary to purchase this from a radio dealer who sells parts and supplies for amateurs as it can not be home-made except by an expert. In order to mount the coil on the wooden base, it will be necessary to make a bracket from a strip of sheet metal as shown in the sketch above. The bracket is slipped over the studs on the bottom of the coil and fastened with two "hex" nuts. The coil can then be fastened to the wooden base in an upright position by two wood screws. There are several oscillator coils for building phonograph oscillators on the market. They are not all exactly like the one shown in the sketch. However, they all follow the same general lines and consist of three small coils and two condensers enclosed in a metal can. When you purchase a coil, make certain that you receive the circuit diagram and instruction sheet that should accompany it, so that you can identify the terminals.

tened in place. Then start wiring. Consult the pictorial circuit diagram and the plan. Use push-back wire and solder all connections. Use only rosin-core solder. As each wire is soldered in place, make a small check with a soft lead pencil mark alongside the corresponding wire on the plan.

Six terminal wires emerge from the bottom of the can enclosing the oscillator coil. Five of them are short, one of them (covered with green rubber) is longer than the others. This is the antenna of the oscillator and is left free, that is, not connected to any of the other terminals on the oscillator.

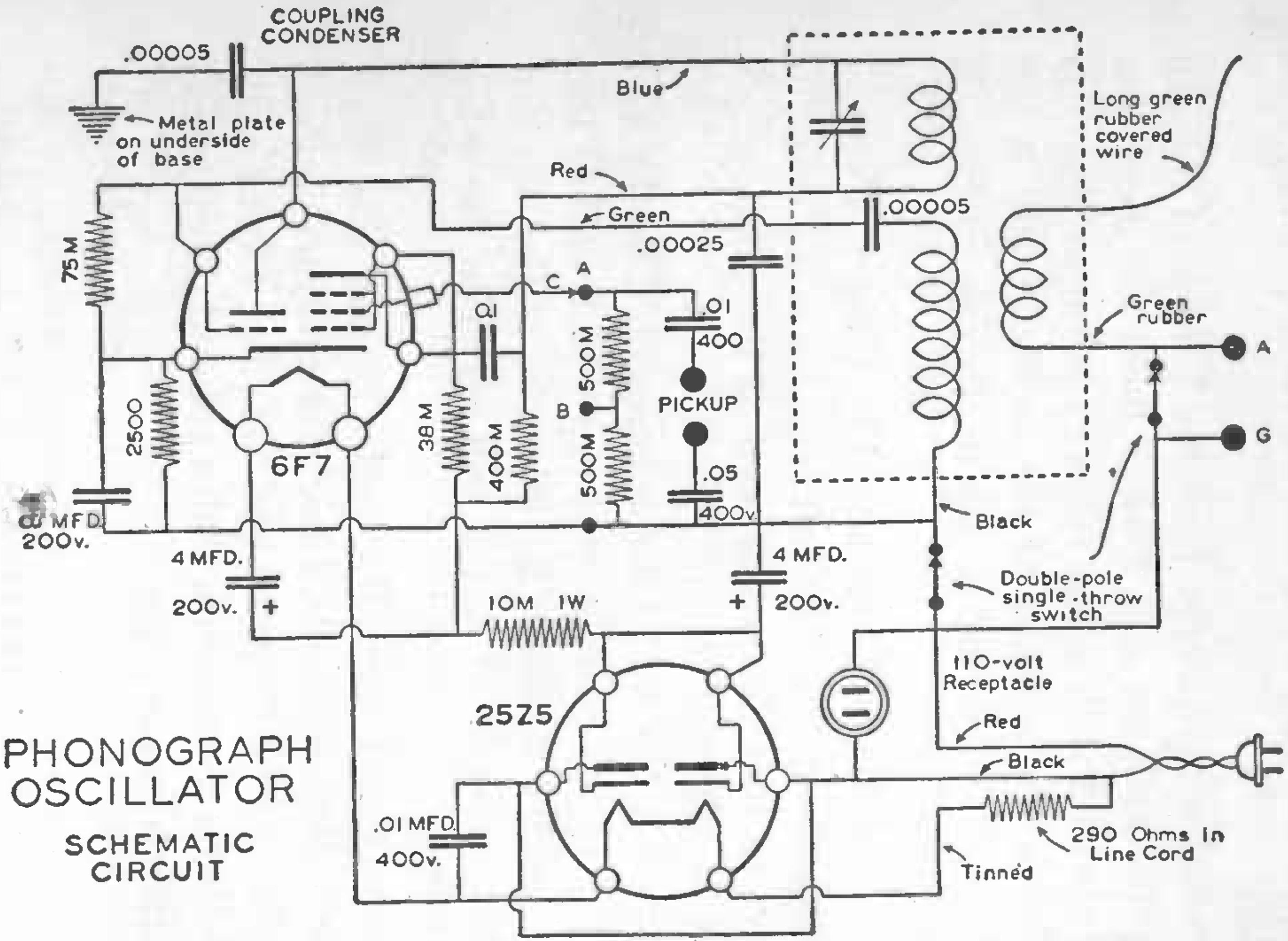
The line cord should be anchored by tying to a screw-eye fast in the base. The 110-volt receptacle is a convenience outlet so that the power cord of the phonograph motor may be plugged into it.

The grid on a No. 6F7 tube is connected to the terminal on top of the bulb. A grid cap which will fit this terminal is needed. Solder a flexible wire to the cap and make it long enough so that it will reach to the 4-lug mounting strip.

Work slowly and carefully; make certain that each connection is properly made. Check for accuracy against the schematic circuit diagram and the plan. Check each wire carefully on the diagram with a colored pencil as explained earlier in these pages.

TESTING

When the wiring has been checked and found complete, the oscillator is ready to be tested. In making the



PHONOGRAPH OSCILLATOR

SCHEMATIC CIRCUIT

The arrow head marked "C" is the wire connected to the grid cap. The round black dots marked "A" and "B" are the terminals on the grid strip marked "A" and "B" on the plan. The dotted rectangle represents the shield enclosing the oscillator coils and condensers. The condenser crossed by an arrow is the variable condenser fitted with a knob. The .00005 condenser is also inside the can but can be adjusted only with a screw-driver.

first test, the oscillator should be placed near the receiver. They should be within three or four feet of one another in the beginning of the test. They can be moved farther apart later.

Put the tubes in the proper sockets, connect the pickup to the binding posts, and plug the line cord into a 110-volt outlet. Turn the switch so as to send the power into the tubes. When the tubes have become warm (it usually requires about a minute), start a record playing on the record player. If there is a volume control on the pickup, turn it to "maximum" or "full." Turn the volume control on the radio receiver to the approximate position used when listening to near-by broadcasting stations. Starting at one end of the broadcast band, tune the receiver as if looking for a station. Search the dial carefully and at some point in the broadcast band the phonograph record will be heard. Tune it in the same manner as if listening to a broadcasting station.

If the sounds of the phonograph record are interfered with by strong signals from a broadcast station, it will be necessary to change the frequency of the oscillator. The frequency of the phonograph oscillator can be shifted back and forth along the broadcast band by turning the knob or the adjusting screw, or both, on the oscillator coil. Change the frequency of the oscillator until the phonograph signals come in at a point on the receiver dial where there is no interference.

Then, if everything is working satisfactorily, you can move the oscillator and the record player farther away from the receiver, to another room or perhaps up or down stairs.

"TROUBLE-SHOOTING"

If the various resistors, tubes, and condensers are perfect and the wiring has been properly done, the oscillator will operate. If you have trouble and suspect that any of the resistors and condensers are imperfect, have them tested by a good radio serviceman.

Here are some suggestions for "trouble-shooting."

It is normal for the line cord to become quite warm when the oscillator is in operation.

If touching the pickup arm produces a humming noise in the radio receiver, the connections from the pickup to the binding posts on the oscillator should be reversed.

If the phonograph signals heard in the receiver are raspy and distorted it may be due to over-modulation produced by too much voltage from the phonograph pickup. Poor quality of sound on loud notes will usually be due to over-modulation and can be corrected by shifting the flexible grid lead from the No. 6F7 tube from lug A to lug B.

The oscillator will operate from a 60-cycle, 110-volt source, either A.C. or D.C. It is not designed to operate on twenty-five cycles.

If your broadcast receiver has been installed by a professional radio man and is connected to the antenna by a transmission line and coupler, the oscillator may not work satisfactorily unless connected directly to the receiver.

DIRECT CONNECTION

Under some conditions it will be found that a direct connection between the oscillator and a broadcast receiver will give much more satisfactory results than with radio operation.

If there is much "man-made" static due to vacuum cleaners or other electrical devices in the same building, a direct connection will give much more satisfactory results.

To make a direct connection between the oscillator and an ordinary broadcast receiver, disconnect the antenna from the receiver and connect it to the binding post marked A on the oscillator. Connect a wire from the post marked G or GND on the receiver to the post marked G on the oscillator. Connect a wire from the post marked A or ANT on the receiver to the long green wire which projects from the bottom of the oscillator coil can.

If the oscillator is to be used permanently, connected directly to the receiver, it is well to short-circuit the .00005 Mfd. condenser marked "coupling condenser" in the diagrams.

DOUBLET CONNECTIONS

Some broadcast receivers which will also receive short waves employ a "doublet" antenna. If it is desired to use a direct connection between the phonograph oscillator and a receiver using a doublet antenna, this is how to do it:

You will find that one side of the doublet connection is connected to a post on the receiver marked D or some designation other than antenna and ground. Do not disturb this connection. Connect the binding post on the receiver marked A or ANT to the green wire projecting from the oscillator coil can. Connect the G or GND post on the receiver to the post marked G on the oscillator.

HOW TO CONNECT A MICROPHONE TO THE OSCILLATOR

You can use your phonograph oscillator as a low-powered broadcasting station which will transmit speech to your radio receiver. A small permanent magnet type speaker costs less than a good microphone and may be used in its place. Simply connect the speaker to the two binding posts on the oscillator in place of the pickup. Or connect the speaker, pickup, and a double-pole, double-throw switch as shown in the illustration. Then either the speaker or the pickup can be almost instantly connected to the oscillator.

You can announce your records or call upon your friends to make a speech over your radio. It is well to remember that the signals may be picked up by a radio receiver located in the house next door or in the next apartment.

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