MAKE RADIO YOUR HOBBY

by

FRED H. STIENING

Written especially for

the Blind

THE AUTHOR

Fred H. Stiening, the author of this Radio Primer, is partially blind and the presentation of these radio lessons is based upon his own experience in meeting the difficulties encountered by the handicapped person.

Mr. Stiening has long been interested in radio work. He is the operator of Amateur Radio Station W8FIP of Pittsburgh, Penna., and is engaged in radio service work, as an occupation.

For the past few years Mr. Stiening has been very much interested in presenting this subject to the blind and other handicapped persons, and a number of these have already obtained amateur stations through his assistance.

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A greatly simplified story of the technical side of radio, together with complete information for building several experimental model radio receivers, written for those persons who have had no previous interest in the "workings" of radio. If you would like to gain some idea as to how this modern "miracle" really works, and if you find the technical articles in the popular radio magazines rather complicated and confusing, then this book is especially written for you.

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CHAPTER I - GETTING ACQUAINTED

Radio has added several thousand new words to the dictionary, it is said. Such words and phrases as "condensers," "transformers," "tubes," "dynamic speakers," "automatic volume control" and many others, all have a familiar ring to the ears of most people now-a-days. Then again, you hear your favorite radio announcer say that such and such a station is operating on "980 kilocycles" or perhaps on "1500 kilocycles." Or some foreign "short wave" station announces that they are transmitting on "25 meters."

Just what is it all about? What do all these new words really mean and how are they all related, the one to the other? It is the purpose of this book to build a greatly simplified technical background around these words, leading up to a practical working knowledge of the subject for those who wish to take an active part in radio work, "Amateur Radio," as a hobby, etc.

A radio is such a motionless, inert, piece of apparatus. A few knobs on the front can be turned, it is true, but inside the cabinet there seems to be very little activity; no wheels turning; just a lot of silent parts and a lot of connecting wires. However, if you should touch your fingers among the wires you are likely to get a good "tickling" shock. FOR RADIO IS PURELY ELECTRICAL IN OPERATION. ELECTRICITY IS ITS "LIFE BLOOD." Everything that goes on in these "condensers," "transformers," "tubes," etc. is electrical. So, to understand these things we must become more conscious of the electrical activities that are going on inside the radio parts.

For example, we stretch up a piece of wire out of doors and call it an "aerial" or "antenna." This wire picks up what is called a "radio wave" out of the air or "ether" and brings it into the radio set to be used by it. In reality, the aerial has picked up a very, very small amount of the ELECTRIC POWER that has been scattered by the broadcasting station that is being listened to. You have undoubtedly heard a certain

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station announce that they are operating with 50,000 watts of power. This means that they are scattering 50,000 watts of power into the air or "ether" and that your aerial is picking up its very tiny share of this power. The aerial actually picks up a very small amount of electricity.

Then again, we plug the radio into the house-current. This is the source of power for all the parts in the set; the tubes, the transformers, etc., they are all kept going by this house-current electricity. It's all electrical, from beginning to end. Even the loud-speaker is vibrated by the electricity that is flowing through it.

So our first lessons will be spent in studying a bit about electricity, as it is used in practical radio work. This will make it much easier to understand the "hook-ups" or connections in radios and to figure out the trouble when it "wont work."

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CHAPTER II - THE ELECTRIC CIRCUIT

Perhaps when you have plugged an electric lamp into the wall socket you have thought of the electricity as simply "shooting out" over the two wires to the lamp at the end of the cord to be used up by the light bulb. THIS IS NOT THE CASE. The electricity actually flows out the one wire, then through the light, then back on the other wire. In other words, the electricity leaves the power house and follows the one wire to your light bulb, is then pumped through it by the electric generator at the power house, and then returns by the other wire to the power house. This is known as an "electric circuit," because the electricity has made a complete circle or loop. All electricity always flows in such complete circles or "circuit."

This electric circuit action can be nicely illustrated by comparing it with our city water supply. Here we have a pumping station which pumps the water from the river through the pipes which lead to our home. Then we use the water and finally pour it into the sewer pipes so that it may flow back to the river. Thus it makes a complete loop or circuit. Our electricity works in about the same way. It is pumped to us by the generator at the power house, it does some useful work for us, and then returns to the power house.

You will notice in these examples that we always need a pump or "generator" to keep the water or electricity circulating through the circuit. This is always the case. The generator at the power house simply keeps pumping the electricity through the circuits that are connected to it. Also, any electric battery, such as used in flashlights, or the larger "storage batteries" such as used in automobiles; all are electric pumps to keep the electricity circulating through some piece of electrical apparatus connected in the circuit.

Now, if we cut the wire at any point in the circuit, the electricity will naturally stop flowing as the loop is then broken. This is exactly what the electric switches

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Now, if we cut the wire at any point in the circuit, the electricity will naturally stop flowing as the loop is then broken. This is exactly what the electric switches

in your house do. They "open" or "close" the circuit as you wish.

Now you may be wondering, "Is electricity just like water"? Well, of course it isn't, but its action can be explained so nicely by comparing it to water that this comparison will be used quite frequently. Electricity is such an intangible thing. It has no body or material substance to it. Outside of being shocked by it, our five senses can take little note of it. Just WHAT it is, is still open for tremendous investigation, but we are mostly concerned here with HOW IT ACTS and how to USE and CONTROL it.

In Fig. #1 we have a sketch of the simplest sort of electric circuit. A small electric lamp is shown connected to a dry cell battery. The two terminals on the top of the battery are connected with copper wire to the two connections on the socket for the light bulb. When these connections are made, the lamp will light and will continue to light so long as the battery has any power to keep the electricity circulating. The power of such a battery comes from the action of certain chemicals put into it. The battery will continue to have power until the chemicals have been "eaten away."

From all of this you will realize that the amount of electricity that can be circulated will depend entirely upon the power of the generator. The flashlight battery is about the smallest generator of electric power that we find in common use, while the tremendous generators at Boulder Dam in Colorado develop enough power for all the needs of several states.

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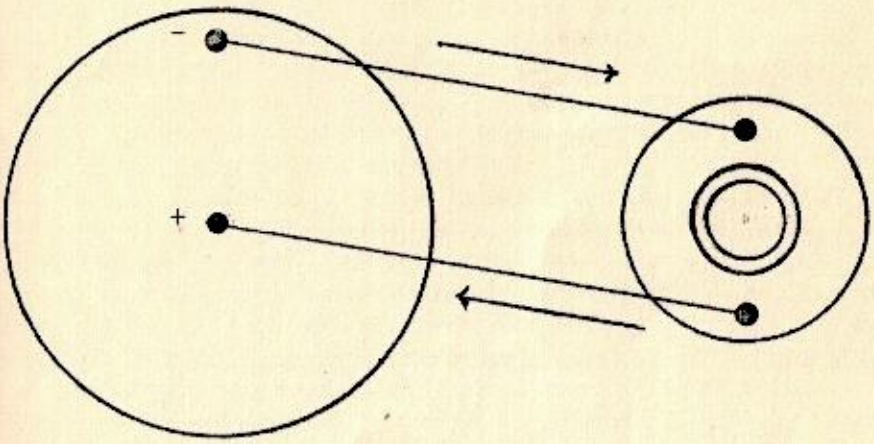
Fig. #1. A Simple Electric "Circuit."



Dry Cell
Battery

Light Bulb
Socket

The arrows indicate the direction of the flow of current in the circuit, which is from the negative terminal of the battery to the positive.

Of course the light bulb has a continuous wire inside of it, to complete the circuit.

Instead of the light bulb, you might substitute a doorbell, or a "buzzer," or even a toy electric motor.

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CHAPTER III - VOLTS, AMPERES, WATTS

We have compared our stream of electricity to a stream of water. In this lesson we shall describe this stream, giving names to its various measurements. In the water example we have "pressure;" we have large and small diameter pipes; long and short pipes and all of this has to do with just how much water we get at our homes. If the pressure is strong and the pipe is large, we will get a lot of water out in a hurry. So it is with our electric stream. If the pressure created by our generator or battery is high and the size of the flow of current is great, then a lot of power will be circulated. Now for some definite terms. In electricity, the pressure is called the "voltage." For example, most power companies supply our homes with 110 volts pressure. On the other hand a flashlight battery or ordinary dry cell has a pressure of only 1.5 volts. The storage battery in an automobile is usually 6 volts, while 25,000 volts or more may be used on high tension power lines used to send power over long distances. The tubes used in most radio sets have approximately 300 volts connected to them. It is voltage or this electric pressure which shocks people and so the higher the voltage is, the more dangerous it is to come in contact with it. Shocks from voltages higher than 110 volts are dangerous and the voltage with which you are working must always be kept in mind.

Now we come to the second measurement of our electric stream. This is the size of the stream and would be compared to the diameter of the water pipe. This is called the "current" and is measured in "amperes." The thickness of a wire determines just how much current can flow on it just like the size of the pipe determines the size of the stream of water that can come out of it. If you try to draw more current along the wire than it can properly handle the wire will get hot. Charts are available showing just how much current each size of wire will carry. An ordinary electric iron usually draws 5 amperes, while a tube in a radio set may draw as little as one thousandth of an ampere. The electric

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"fuses" in most houses are rated at 15 amperes so that if the current drawn is greater than 15 amperes the fuses "blow" or automatically open the circuit and so no damage will be done by the wires getting too hot.

And so we have discussed the two main measurements of our electric stream; namely, "volts" and "amperes." Now, if we multiply the two together, we get "watts." Our electric iron drew a current of 5 amperes at a pressure of 110 volts and if we multiply these together, we will get 550 watts, the actual amount of electric power that is being turned into heat by the iron. Watts is the final measurement of the actual power that is being used or pumped through the circuit. Another example: if we have an electric lamp operating on 110 volts and drawing 1 ampere, that would be a 110 watt lamp. If we have low voltage and low amperage, the power is bound to be low and if both are high, the power will necessarily be high and of course we may have anything between these extremes. If we have a circuit at the power house with 50,000 volts and 500 amperes of current, this would be a power of 25 million watts, enough to supply a good size town.

It is suggested that before going further, you review Chapter #2 and #3 so as to get as clearly in mind as possible these fundamental electrical terms and the story they tell. All of this may seem a bit far from the explanation of the tubes, coils, etc., of your radio, but all of these parts operate on this electricity which we are now examining and we're not forgetting the practical side.

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CHAPTER IV - ALTERNATING & DIRECT CURRENT

This lesson will bring us back to Radio. We are going to find out just what kind of electricity comes in on our aerial wire; just what kind of electricity our radio waves are made of. First, however, we must examine the current in our electric circuit a bit further.

Probably you have wondered, "In just what direction does the current flow around such an electric circuit?" On just which wire does it leave the battery and on which one return to it? Now in some cases the electricity flows always in the same direction around the circuit and if it always does this, it is known as "Direct Current;" flowing in one direction.

However, in other cases, the electricity flows for a short time in one direction, then stops, then REVERSES its direction, and finally stops again. This continuous reversing of its direction of flow around the circuit causes it to be known as "Alternating Current." You have undoubtedly heard of both. Both are found in EVERY radio.

Batteries always generate direct current. Now please refer to Fig. #1. You will notice two arrows on the diagram. These indicate the direction of the flow of current in such a circuit. You will notice that one terminal of the battery is marked with a cross which is called the "plus" or "positive" terminal, while the other terminal is marked with a straight line, which is called "minus" or "negative." ELECTRICITY ALWAYS FLOWS FROM THE NEGATIVE TERMINAL TO THE POSITIVE TERMINAL.

But now suppose we start reversing the wires to our battery (Fig. #1) as fast as we can. The electricity will then have to reverse its direction through the lamp if it is always going to flow from negative to positive. Just picture holding one wire in each hand and then "switching" the connections to the battery as fast as possible. If you could switch it fast enough the light

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wouldn t even go out although the direction of the current through the lamp would be reversed every time you switched the wires. This is exactly what is done in Alternating Current. The positive and negative is switched a certain number of times every second and so the current reverses its direction in the circuit the same number of times. Most power companies supply us with "60 cycle" alternating current; this means that there are 60 complete reversals or "cycles" each second of time. Rather fast switching, wouldn't you say? Of course this is done automatically by the generator at the power house.

Now you are probably wondering - "what is the purpose or advantage of such reversing alternating current?" Why not use direct current? Well it so happens that alternating current can be distributed over large areas and for many miles with very little loss of power, while it is impractical to distribute direct current for more than a few miles. We are not going into the reason for this here as it has no bearing upon our radio work but nevertheless this is the reason why we are usually supplied with alternating current for use in our homes and hence our radios must operate from this kind of electricity. The "hum" which you sometimes hear pouring forth from the loudspeaker of a radio is caused by some of the alternating current unintentionally getting into the speaker circuit.

But now let us speed up our alternating current. Suppose that instead of having 60 reversals or cycles per second, we speed up to 100; then to 1,000; then to one million cycles per second. Just imagine reversing the positive and negative a million times in ONE second. Its almost too fast for the imagination but this is exactly what our radio waves are made of; very high frequency alternating current. When the current is reversed so rapidly, it has difficulty following wires and simply "jumps off" into space. So if we can generate alternating current of very high frequency and then pour it into an aerial wire, it will jump off or "radiate" into the ether to be picked up by some

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distant receiving aerial.

When you hear that a certain station is operating on 980 kilocycles, it means that that station is generating alternating current of 980,000 cycles per second. You see the term "kilocycle" simply means one thousand cycles. The various numerals on the modern tuning dial refer to these frequencies of alternating current. It is this DIFFERENCE IN FREQUENCY that makes it possible to separate the various stations. A "MEGACYCLE" is a million cycles per second.

The "Short Waves" are simply waves of much higher frequency. For example, much of the foreign broadcasting is radiated on 11 megacycles or 11 million cycles. The term "short Wave" usually means any frequency between one and a half million and 30 million cycles per second. The Amateur Stations in the United States are privileged to operate at 1.8 megacycles; 3.5 mc; 7.0 mc; 14.0 mc, and at 28 mc.

Such is modern radio with its many, many stations, all operating on different frequencies and our receiving sets provide the means for choosing or "tuning in" the one station we desire to listen to.

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Such is modern radio with its many, many stations, all operating on different frequencies and our receiving sets provide the means for choosing or "tuning in" the one station we desire to listen to.

CHAPTER V - FROM AERIAL TO LOUDSPEAKER

As mentioned previously, our aerial picks up a very tiny bit of electricity from the ether and feeds it into our radio. Then, finally, from the loudspeaker we get a variety of sound vibrations -- our radio program. But what are the intervening steps through which our radio signal must pass until it finally reaches the loudspeaker?

All modern radio receivers must perform the following distinct functions:-

1. "Tuning". This is the means of selecting the one desired station (frequency of Alternating current) from all the others that the aerial is picking up. Some radios have extremely effective tuning systems, especially superheterodynes, and such receivers are said to be very "selective", having the ability to select the desired station from all others, even if it be a very weak distant station. Other radios, especially the small 4 tube sets, have very little selectivity and two or more stations may be heard at the same time. Adjusting the tuning dial will not separate them. Such a radio is said to tune "broad". "Tuning" is one of the major functions of our radio.

2. "Amplification". The very weak signal which our aerial picks up must be greatly amplified, magnified, or built-up before it can vibrate the loudspeaker with normal volume. This amplification is provided by the radio "tubes". The signal may be amplified a million or more times in its trip from aerial to speaker. You can easily imagine what a very, very small amount of electricity is picked up from a station thousands of miles distant. Also consider that perhaps a million other radios are tuned to this same station, each getting its share. No wonder we need to amplify what we receive. This amplifying action of the tubes must be under control, as, naturally, a strong local signal needs

CHAPTER V – FROM AERIAL TO LOUDSPEADER

As mentioned previously, our aerial picks up a very tiny bit of electricity from the ether and feeds it into our radio. Then, finally, from the loudspeaker we get a variety of sound vibrations -- our radio program. But what are the intervening steps through which our radio signal must pass until it finally reaches the loudspeaker?

All modern radio receivers must perform the following: distinct functions:-

1. "Tuning". This is the means of selecting the one desired station (frequency of alternating current) from all the others that the aerial is picking up. Some radios have extremely effective tuning systems, especially superheterodynes, and such receivers are said to be very "selective", having the ability to select the desired station from all others, even if it be a very weak distant station. Other radios, especially the smaller 4 tube sets have very little selectivity and two or more stations may be heard at the same time. Adjusting the tuning dial will not separate them. Such a radio is said to tune "broad". "Tuning" is one of the major functions of our radios
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less amplification than the very weak distant signal. The "volume control" provides us with the means of controlling the amplification of the tubes.

3. "Detection". This is the means of separating the music or voice sounds from the alternating current radio wave which carried it through the ether. Every radio must have such a "detector". It is usually a tube but in some very small radios a "crystal" detector is used. Detection will be explained more fully later.

4. Loudspeaker or Headphones. After we have selected, amplified, and detected our radio wave, we are then ready to change this vibrating electricity into vibrating sound waves. For this we use a loudspeaker or headphones. In this piece of apparatus there is either a metal or parchment "diaphram" which is vibrated to produce sound.

5. "Power Supply". All the tubes in our radio must be supplied with power so that they may "amplify" "detect", etc. The electricity we usually have in our homes is not satisfactory for use on the tubes. And so we need a Power Supply to convert or change the 110 volt 60 cycle alternating current, with which we are usually supplied, to direct current of about 300 or more volts. On this power the tubes will function very effectively.

These are the main parts of a radio and now we shall go into more detail.

At this point it is suggested that you get hold of one or more old radios with the intention of taking them entirely apart to become acquainted with the parts. Very few tools are needed for such an undertaking; a screw driver, pair of pliers, and a pocket knife, for cutting wires, being about all. Such radios, being used no longer, may be found in the attics and cellars of many of your neighbors and they

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CHAPTER VI - THE TUNING CIRCUIT

Now for more details on the tuning circuit. Only two parts are used; a coil of wire and a "variable condenser", connected together as shown in the diagram of Fig. #2. At first inspection it may seem rather strange that such odd looking parts can be used to select a station, but it must be kept clearly in mind that high frequency alternating current is being circulated in the tuning circuit formed by these two parts. We are dealing with "RADIO FREQUENCY CURRENT", abbreviated R.F.

The tuning coil consists of a number of turns of copper wire wound on a cylindrical form, made of insulating material, such as cardboard or "bakelite". This form keeps the turns of wire permanently in place. Coils are of various diameters and lengths, depending upon the requirements of the tuning circuit. Also many coils are enclosed in metal cans, called "shield" cans.

The variable condenser is indeed an odd piece of apparatus, consisting of two sets of metal plates spaced something like the teeth of a comb and so arranged that one set of plates will slip through the other set, but without touching each other. These condensers will always be found fastened to the tuning dial. When the dial is turned the one set of plates is rotated. It will be well for you to carefully inspect a few variable condensers at this point. They can always be found fastened to the main tuning dial. Usually two, three or four condensers will be found, built as one unit, all being rotated simultaneously by the dial. Each condenser represents a separate tuning circuit. The more tuning circuits a radio has, the more selective it will tune.

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of the variable condenser, let us first examine the simplest form of condenser. A "condenser", in its simplest form, is merely two metal plates separated by some insulating material. For example, suppose we place a piece of tin foil on the table, then cover it with a piece of tissue paper, and then lay on top another piece of tin foil. In this fashion we will have two pieces of metal, close together, but nevertheless insulated from each other by the tissue. THIS IS A CONDENSER. Of course if we were to wire the condenser into a circuit, we would make connection to the two metal plates. Another example of a condenser, on a huge scale, is the clouds and the earth. The clouds represent one plate and the earth the other plate, and the air between is the insulating material. If electricity of sufficiently high voltage is generated in the clouds, it suddenly breaks through the insulating material (the air) and discharges to the ground, and we call it "lightning". It is this electrical effect between the two insulated plates that is of interest to us in radio. A "fixed condenser" is one in which the surface of the plates, or "capacity", cannot be changed, while in a "variable condenser" we have the means of varying the surface, or capacity, by rotating the plates in and out of each other. In any condenser, the more surface the plates have, and the closer they are placed to each other, the more capacity the condenser will have.

Now what is the electrical purpose of such condensers and coils? How do they function in selecting our radio frequency current wave? First let us see what happens in the coil.

If we connect a coil in a circuit and try to pass high frequency alternating current thru it, we will find that such current has great difficulty in "spinning around" such a coil. If the wire was taken off the coil and stretched out straight, the current would have no difficulty, but when the wire is wound in the form of a coil, the current is held back. The more turns in the coil, the more difficult it is for the

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current to follow through it. Also, the faster the frequency of the r.f. the more the current is held back. This "holding back" of the alternating current by the coil is called the "inductance" of the coil. The coil contributes this "holding back" action for our tuning circuit, and this is half of the tuning action. Now let us see what the variable condenser does.

The variable condenser acts just the opposite of the coil. Instead of holding back the radio frequency current, it lets the current pass right through it. The more capacity the condenser has, the easier the current can "jump" the space between the plates. Also, the faster the frequency, the more easily it jumps. And after all, if the current can jump the hundreds of miles between the broadcast station and your aerial, you can see how easily it can jump between the plates of a condenser.

Now if we connect the coil and the variable condenser together as shown in Fig. #2, thus combining the "holding-back" of the coil and the "letting-through" of the condenser, we have a selecting arrangement. The coil holds certain stations back, while the condenser wants to let the stations through; they compromise and let ONE station through, the one we want. A certain amount of capacity connected across a certain amount of inductance, as shown in Fig. #2, will always tune to some particular frequency of alternating current. If we want a different frequency we must change either the capacity of the condenser or the inductance of the coil, or both.

All of this might be compared, to some extent, with the tuning of the "strings" on a musical instrument. They must be tuned to a definite vibration. To do this we change their lengths; we adjust the tension on the string, and finally it is tuned to a definite frequency of vibration. Of course in our radio tuning, we are dealing with vibrating electricity instead of vibrating sound waves.

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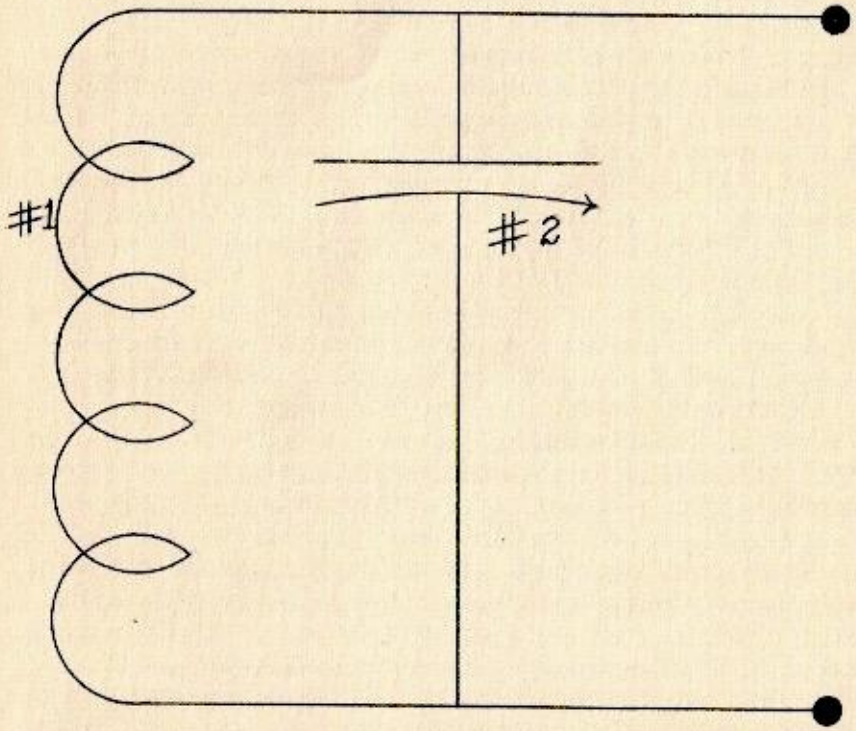
It is indeed suggested that you study this chapter most carefully, as an understanding of capacity and inductance in radio circuits is most helpful. To further clarify the subject we shall next describe a crystal detector radio receiver in detail, showing how such a tuning circuit is used in an actual "hookup."

Fig. #2 - The Tuning Circuit.



#1 is the tuning coil. The number of "loops" shown on the diagram does not mean the exact number of turns in the actual coil. The diagram shows four loops whereas the coil, it represents, might have 55 turns.

#2 is the variable condenser. The heavy straight line represents the fixed, or "stator" plates, which do not move. The heavy curved line, with the arrow head, represent the "rotor" plates, which are turned by the tuning dial.

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CHAPTER VII - BUILDING A CRYSTAL DETECTOR RADIO RECEIVER

Now for a bit of fun - let us build a crystal detector radio receiver. It is very simple, consisting of but four radio parts; a tuning circuit, with its coil and variable condenser; a crystal detector; and a pair of headphones. These parts are connected together as shown in the diagram of Fig. #3.

The reception from such a radio is very clear in tone, and if you can hang up a good aerial of say 75 to 100 feet in length out in the yard, you will receive stations 25 miles or more distant. No batteries or electric power of any sort is needed. You simply get it all "out of the air."

You will notice from the diagram that we have added an extra coil to our tuning circuit. This coil is connected between the aerial and the ground connection. This coil keeps the length of the aerial and ground wires from disturbing the tuning of the tuning circuit, but nevertheless feeds the signal into the tuning circuit. Then by adjusting the variable condenser, we select the station we wish to hear. This signal is then passed through the circuit consisting of the crystal detector and headphones. The crystal detector separates the voice and music from the r.f. wave and the headphones change this vibrating electricity into sound.

In building such a set the exact arrangement or placing of the parts is not critical, although it is a good idea to keep the parts close together, so that the connecting wires will be short. The coil may be wound on cardboard tubing 2 or 3 inches in diameter with 30 to 50 turns of copper wire for the tuning circuit and 10 to 15 turns for the aerial coil. The coils are wound along side of each other on the form, with a space of one quarter inch between them. The wire used in winding the coil is usually called "Magnet" wire and size #22 is very satisfactory for such a coil. Such wire is furnished either "enameled" or

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"cotton" or "silk" covered so that the turns will not make contact with each other when wound on the coil. Of course this insulation must be scraped off wherever a connection is to be made, such as at the end of the wire. In this crystal set the exact size of the coil, size of wire, etc. are not critical. Just use what you can easily get hold of and try your luck. It may be interesting to make several coils of different sizes to note the difference they make in the tuning.

The variable condenser may be one having 23 plates, although this isn't critical either. Such a condenser is rated as having a capacity of .0005 microfarads and can be taken from an old radio or purchased from a radio parts store. Connections must be made to the two sets of plates.

The crystal detector should be purchased. Two types are available. One is called a fixed crystal detector and this type requires no adjusting. The other type is adjustable, having a thin wire to be moved about on the crystal. This adjustable type is usually more sensitive and a bit more interesting to experiment with. There are two connections to be made to the crystal detector.

So try your luck at making such a radio. There is nothing difficult about it and if you live within 25 miles of a broadcasting station, you should have no trouble picking it up and possibly a few amateur stations will come in for good measure.

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Fig. #3. A Crystal Detector Radio Receiver.

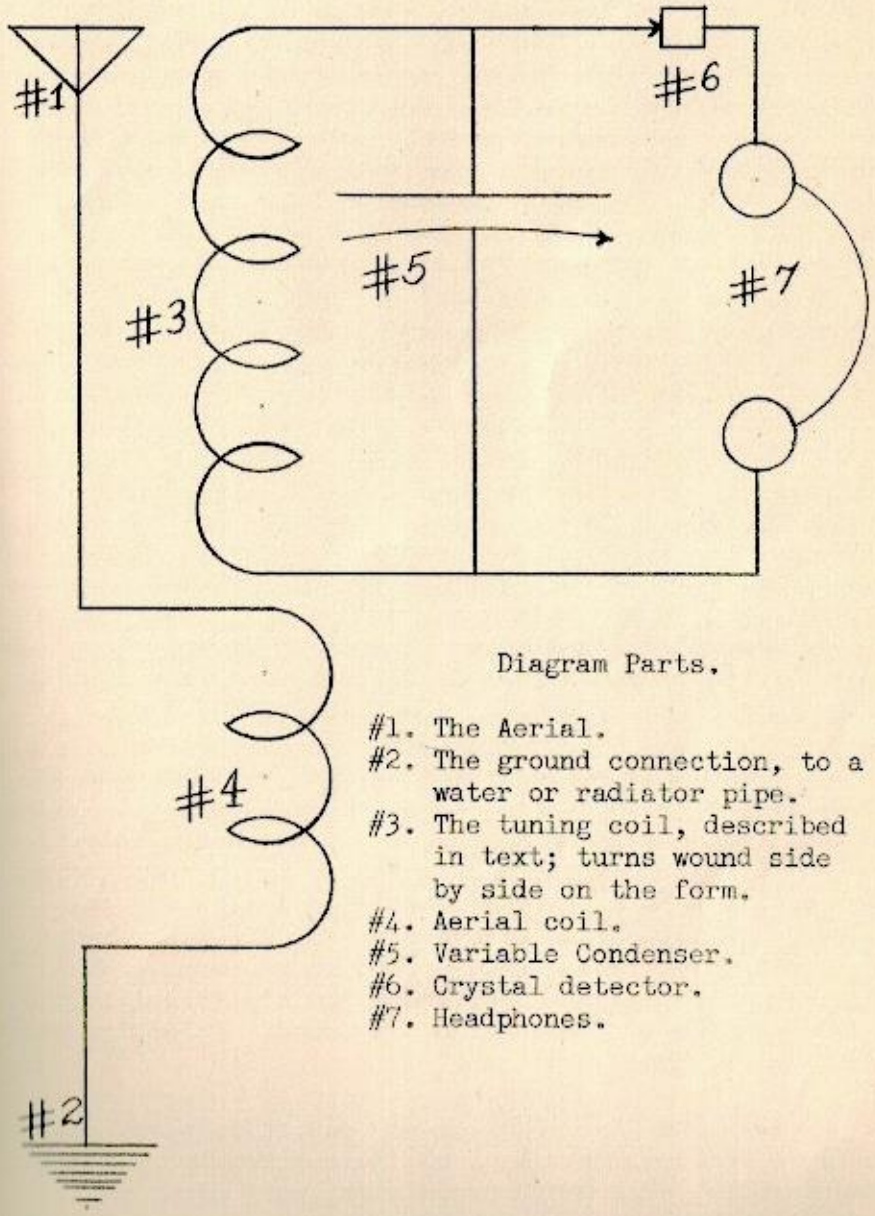

Diagram Parts.

#1. The Aerial.
#2. The ground connection, to a water or radiator pipe.
#3. The tuning coil, described in text; turns wound side by side on the form.
#4. Aerial coil.
#5. Variable Condenser.
#6. Crystal detector.
#7. Headphones.

CHAPTER VIII - THE RADIO TUBE

If you have built and operated the crystal receiver, you have undoubtedly noticed that it has several serious shortcomings. For one thing, it has very little volume; it will not operate a loudspeaker. Also its receiving range is limited to a short distance; it is not very sensitive. Also you have very likely been annoyed by its poor selectivity, as it tunes very broadly. However, it is the best that you can expect if you are simply going to pick the signal out of the air and turn it into sound. If we want to get more volume from our radio we will have to add some electric power of our own to produce the greater volume; we simply cannot get it out of the air. So for a more powerful radio, we supply power and simply let the signal coming in on the aerial CONTROL THE FLOW OF THIS POWER to the speaker. The power may be furnished by batteries or from the electric socket.

And too, if we are going to add power, our receiver will naturally become more sensitive to weak distant signals; also we can use SEVERAL tuning circuits, instead of one, and thus obtain much more selectivity. All of these desirable results can be secured if we can but add power to our radio signal as it comes into the radio. Just furnish power and let the signal CONTROL it.

From this it would seem that what we most need is some sort of an electric valve. Such an electric valve must have the ability to turn our supply of electricity on and off just according to what is being received on the aerial. This valve will have to follow all the electrical vibrations being received; the high frequency alternating current making up the radio wave, a million cycles per second or more; also the electrical vibrations representing the music and sound. It will take SOME valve, don't you think?

Well, the RADIO TUBE is our electric valve. It will give us perfect control of all this vibrating electricity and besides, will serve us in many, many other marvelous ways. Without such tubes, long distance telephone calls

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would be impossible, as the electrical vibrations would "die out" on the long wires. Tubes are the heart of the apparatus used to "amplify" the voices of public speakers in large auditoriums, etc. And as one more interesting example, the Talking Book depends upon the amplifying action of these tubes to reproduce the voices recorded on the records. Many other uses have been and are being found for these tubes daily and their development represents one of the greatest achievements in electrical research. Of course, in this book, we are going to discuss these tubes only as they are used in radio.

In radio these tubes are used for many purposes. First to amplify the very weak signals picked up by the aerial. The signals picked up from a weak distant station may be amplified thousands upon thousands of times by the action of these tubes.

Several tubes may be used to get sufficient amplification. Then again, a tube is used to separate the voice and music sounds from the radio frequency wave which carried it through the ether. This tube is called a "detector tube." Then we will probably have other tubes to amplify the sounds after they come from the detector tube, to whatever volume we desire, even to filling an auditorium. Also tubes are used to change alternating current to direct current. Such a tube is called a "Rectifier tube" and is used in the "power supply" of electric radios. Then again, we can use a tube to GENERATE alternating current from direct current. Yes, we can generate high frequency alternating current from batteries, with the help of a tube; and this is the "beginning" of a radio transmitter. All of these things the tube will do for us in our radio work, if we but get it "hooked-up" right and supply it power to work with.

Now let us examine these tubes a bit more closely. In the first place, it consists of a glass shell, something like an electric light bulb. Inside the glass bulb there are a number of very small metal parts and wires. At the bottom of the tube there are a number of

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Now let us examine these tubes a bit more closely. In the first place, it consists of a glass shell, something like an electric light bulb. Inside the glass bulb there are a number of very small metal parts and wires. At the bottom of the tube are a number of

metal connection pins. Modern tubes may have anywhere from four to eight such connection pins at the base, and many tubes have in addition one metal connection coming out of the top through the glass. All of these pins make connection with the various metal parts inside the tube. Also in all tubes, the air is pumped out, just as it is in electric light bulbs, except that in radio tubes the pumping is far more thorough, so as to remove as much of the air as possible. This is why such tubes are often called "vacuum tubes". All the small metal parts or "elements" inside the tube are insulated from each other, so that the only connection each element has is with its own pin at the base of the tube. Thus in an ordinary five pin tube we might have a "plate element" inside the tube connected to the plate pin at the base; a "grid element" to the grid pin; a "cathode element" to the cathode pin; and a "heater element" connected to TWO pins, thus making use of all five pins at the base of the tube. It might be well to break open a few old tubes at this point to become more familiar with their mechanical construction. However, be careful not to cut yourself with the sharp broken glass. The metal elements in a tube are very small and closely placed together and the spacing and insulation between the elements is very important. Of course tubes should be handled with care, as dropping them may easily disturb the spacing of the elements, even though the glass does not break.

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CHAPTER IX - HOW TUBES WORK

Now we come to a discussion of the electrical action within one of these tubes. It must be kept clearly in mind that a tube is an electric valve; that its purpose is to start and stop the flow of electricity in a circuit; that it does this INSTANTLY, a million times or more a second, if necessary.

So, in the first place, our tube must be included in one or more circuits, so that it will have the opportunity to turn the current on or off. These circuits must be complete loops as described in Chapter II. The electricity must be made to flow through the element of the tube and that is where it is controlled.

Now let us examine the elements in a simple five pin tube, such as is used in many electric radios, and see just how the elements are connected in the circuits to give such control. Such tubes bear any of the following numbers: 27 - 37 - 56 - 76. The tube consists of four elements: a "heater"; a "cathode"; a "plate"; and a "control grid". All of these are insulated from each other and have absolutely no connection with each other in the vacuum of the tube.

The heater is something like the filament of a light bulb and its purpose is to get hot, as its name implies. These heaters are ordinarily operated on either two and one half volts or on six and three tenths volts, either alternating or direct current can be used. They are not operated on 110 volts as is the case with our light bulbs. The heater element uses two pins in the tube base, just like the two connections needed for a light bulb. The heater can be operated from either a transformer or batteries, giving the correct voltage. When the heater has been connected to the battery or transformer, so that it will heat, this is known as the "heater circuit".

In Fig. #4 we have a series of four very simple diagrams showing the various elements of a tube. In a radio diagram, a large circle always represents a tube, and the lines inside the circle represent the various

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elements inside the tube. For example, in Fig. #4a we show the heater only. These sketches do not represent the actual shape of the parts inside the tube, but make it easier to understand how the tube works in the circuits.

The cathode is a sort of a metal sleeve placed around the heater, so as to absorb its heat. As mentioned previously the cathode has no electrical connection with the heater. Now this cathode is made of a special metal, which when it becomes heated by the heater, gives off a "cloud of electrons". These electrons are simply NEGATIVE particles of electricity.

It is something like boiling a bucket of water. When the water gets hot enough, a cloud of steam will be boiled off. In somewhat the same way our electrons are "boiled off" the cathode and are left free to wander around in the tube. You may ask, why doesn't the heater give off electrons? After all it is hot too. But it is not made of the proper sort of metal to do this. We don't want it to give off electrons because if it is heated with alternating current, as it is in most electric radios, this might cause a "hum" in the radio. The cathode and heater are diagramed in Fig. #4b.

Now that we have this cloud of negative electrons floating about inside the tube, what are we going to do with them? How can they be used to produce this electric valve action? Well next we shall add another element to our tube. This element is called the "plate". It is another metal sleeve, a good deal larger in diameter than the cathode, so that it can be made to surround the cathode with some space between them. The plate, cathode and heater are diagramed in Fig. #4c.

Now it is to this plate element that we connect the power which we wish to control. Refer to Fig. #5a. In this experimental diagram we have a pair of headphones and a 45 volt dry battery (called a "B" battery) connected between the plate and cathode. You see we now have a complete circuit, except for the break inside the tube

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between the cathode and plate. If we can just get the current to "jump" this space, we will have a complete circuit and the current will be circulated by the battery through the tube and phones. The negative electrons form this connection, or sort of a "bridge" from the cathode to the plate, that is their purpose. However, for this to happen, WE MUST HAVE THE POSITIVE TERMINAL OF THE BATTERY CONNECTED TOWARD THE PLATE AND THE NEGATIVE TERMINAL CONNECTED TOWARD THE CATHODE. You see, the NEGATIVE electrons are only attracted to the plate when it is POSITIVE. "Opposites attract." In this manner we include the plate and cathode elements in a circuit, and the flow of current is entirely dependent upon the flow of electrons from cathode to plate. This circuit, as just described, and as shown in Fig. #5a, is called the "plate circuit" of the tube. Disconnecting one of the wires to the headphones while the circuit is in operation, will produce a loud "click" in the phones. Otherwise there will be no sound as the flow of current is steady and there is no electrical vibration to be reproduced by the phones.

Now we are going to add the last element to our tube; the "control grid." If we can but control this flow of electrons from cathode to plate, so as to start and stop them at will, then we will indeed have an electric valve. The control grid will do this very thing. It is a wire mesh, something like screening, and is also in the shape of a sleeve. It is placed in the space between the plate and the cathode, so that all the electrons must pass through its openings on their trip from cathode to plate. You see, the control grid is something like a gate. Just to review, the elements of the tube are as follows: the heater is at the center, surrounded by the cathode; then surrounding these is the control grid, and outside of all these is the plate. The complete diagram of the tube, with all its elements, is shown in Fig. #4d.

Now we come to the electrical action of the control grid. This element must also be connected in a circuit, and this circuit is called the "grid circuit." Refer to Fig. 5b. Here we have added a grid circuit to the plate

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circuit which we have already studied. A tuning circuit is shown connected from the grid to the cathode and, for the purpose of this discussion, it is assumed that some sort of alternating current is present in this tuning circuit, ready to be amplified. The action is this. If the grid is made positive by any voltage whatsoever, this positive voltage on the grid will tend to push the electrons with all the more vigor toward the plate; the "grid gate" will be open wide and the plate current will increase. On the other hand, if the voltage on the grid should become negative, then the electrons will be repelled and pushed back to the cathode; the "grid gate" will be closed and the electrons will not be able to flow through to the plate. In this manner the grid circuit has perfect control over the plate circuit. When you recall that in alternating current the positive and negative are continually being reversed, then you can appreciate what an opportunity the grid has to turn the plate current on and off. Thus any fluctuating voltage that is present in the grid circuit is reproduced in the plate circuit and, to top it off, the fluctuations in the plate circuit will be much greater than those in the grid circuit, due to the power that has been added by the battery. It is in this manner that tubes "amplify." They will amplify any sort of vibrating electricity, from the lowest base notes of an organ to the fastest sort of radio frequency alternating current. Indeed the tube is a marvelous electric valve.

In Fig. #5c we show the actual pin connections for this five pin tube. This is a bottom view; that is the tube is viewed with the glass down and the base up. All tubes fit into "tube sockets," so that connections can be made to the various pins. Sockets can be purchased to accommodate tubes having anywhere from 4 to 8 pins.

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DIAGRAMS OF A RADIO TUBE.

Fig. #4a - The Heater.

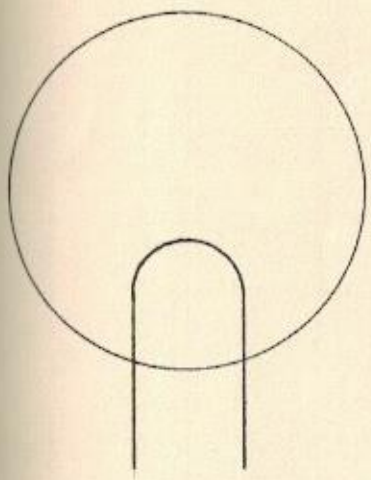


Fig. #4b - The Heater and Cathode.

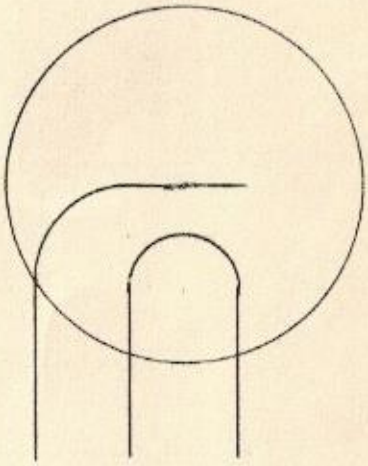


Fig. #4c - Heater, Cathode & Plate.

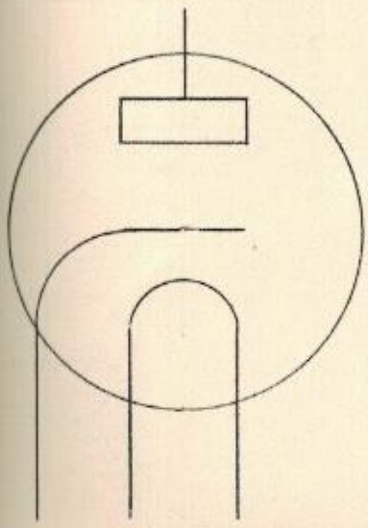
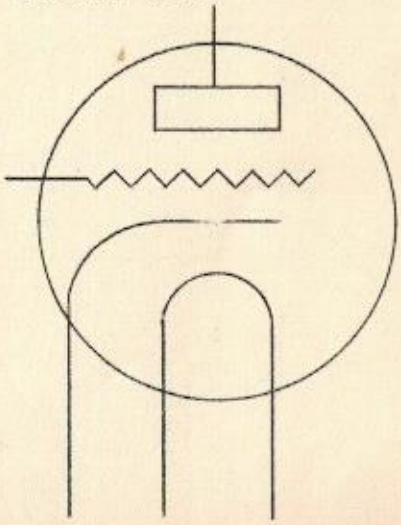


Fig. #4d - Heater, Cathode, Plate & Control Grid.



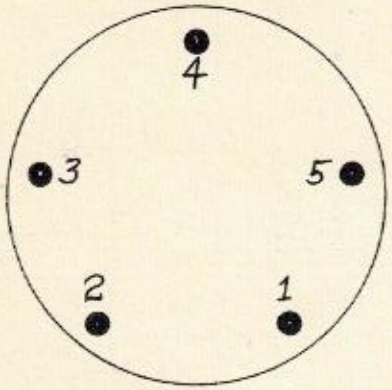


Fig. #5c - Tube Pin connections. Bottom view.
#1 - Heater.
#2 - Heater.
#3 - Plate.
#4 - Control Grid.
#5 - Cathode.

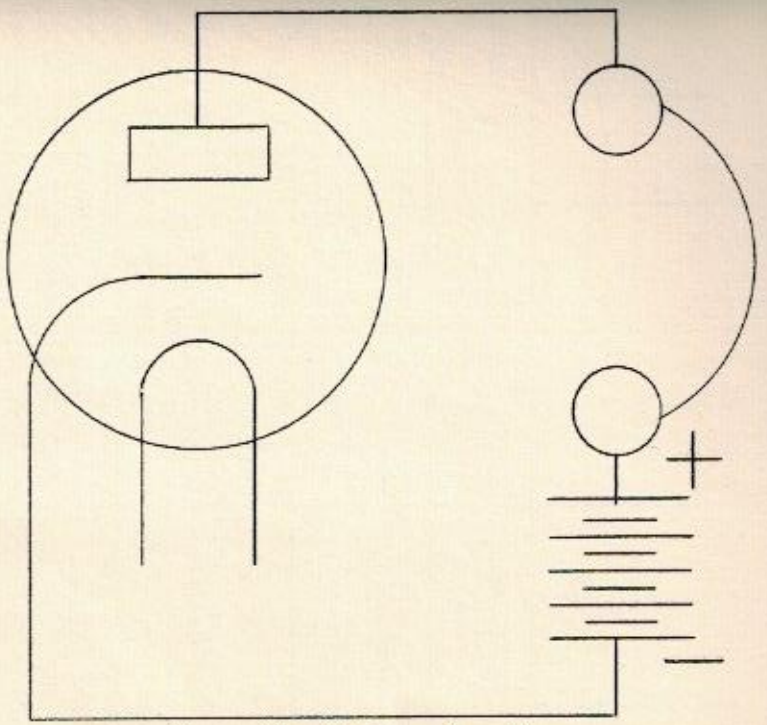
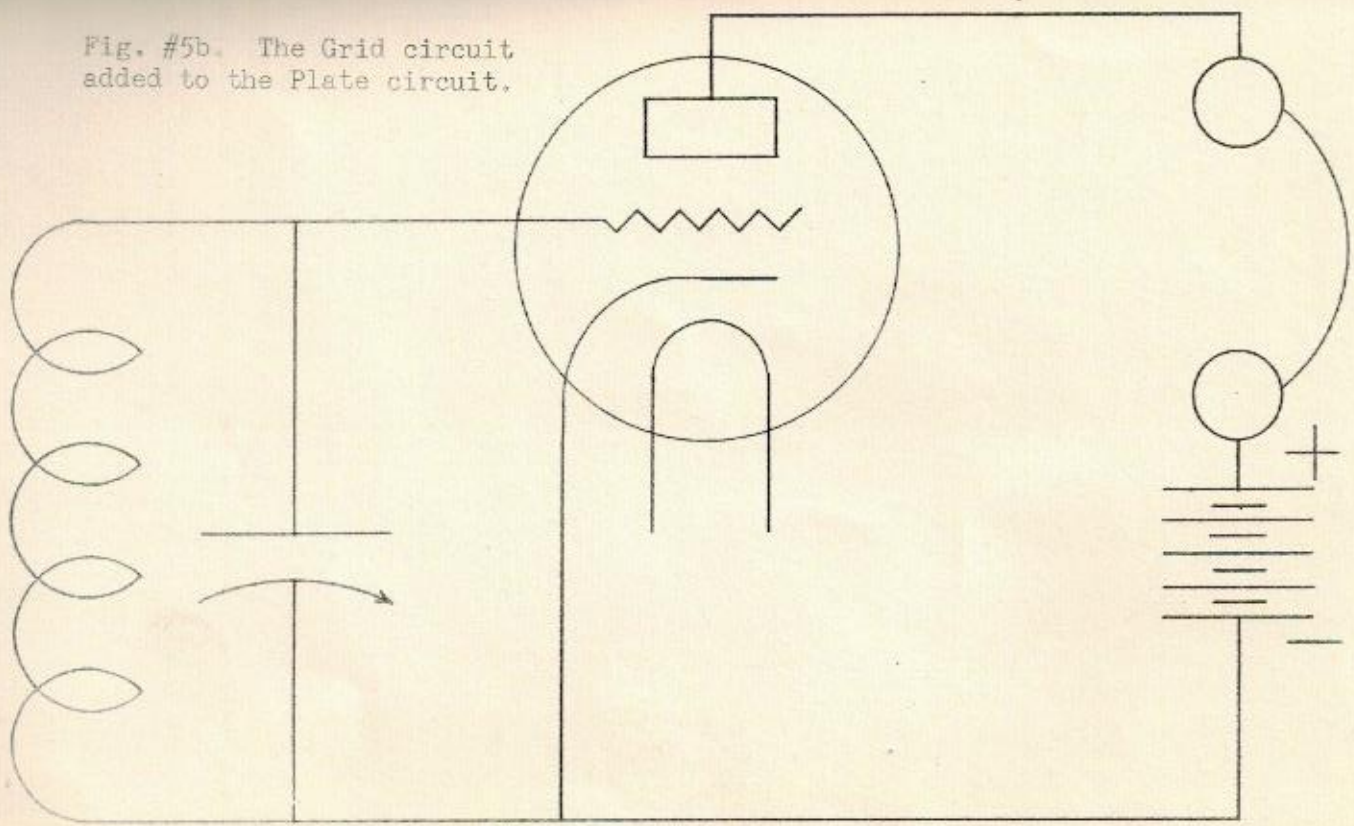


Fig. #5a. The Plate circuit.

Fig. #5b. The Grid circuit added to the Plate circuit.



CHAPTER X - BUILDING A ONE TUBE RECEIVER

In Fig. #6 we show the diagram of the simplest sort of one tube receiver. You will notice that this diagram is very similar to that of the grid and plate circuits of Fig. #5b. However, an aerial coil, such as was used in the crystal set, has been added. Also we have added two parts in the grid circuit; namely, a "grid condenser" and a "grid resistor." The addition of these parts to the grid circuit, causes the tube to function as a "detector," that is, it is used to separate the sound from the carrier wave just as the crystal was used in the crystal set. In this circuit the tube is NOT an amplifier. It is suggested that you experiment with a receiver of this sort. It will give you a fine chance to get better acquainted with the action of the tube. There is nothing critical about the placing of the parts and you should have no trouble getting it going.

The tuning and aerial circuits can be the same as was used in the crystal set. The heater of the tube should be supplied with either alternating or direct current of the correct voltage for the type of tube used. For the type 27 or 56 tube, 2.5 volts is necessary; for a type 37 or 76 tube, 6.3 volts is used. It will be quite satisfactory to heat the tube from an electric train transformer, if you happen to have one, or you may purchase a regular "filament heating" transformer. Just be sure that the tube and the transformer voltage are the same.

The plate circuit "B" battery should be of the 22.5 volt type, preferably having "taps" or connections at other voltages. This battery can be purchased from a radio parts store. The taps may be used in experimenting with various voltages to the plate of the tube. It will be found that a certain voltage will give the loudest signals.

Now a few words about the grid condenser and grid resistor. The grid condenser is a fixed condenser with a capacity of .00025 mfd. A Sangamo type "A" condenser is suggested for this purpose. The wire connecting it to the grid terminal of the tube should be as short as

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practical. The grid resistor should be of 5 megohms size. This means 5 million ohms. Any resistor in a circuit tends to hold back the flow of current in the circuit, just like a water pipe "clogged" with dirt, would tend to hold back the flow of water through the pipe. The "ohm" is the measurement of this holding back of the current by the resistor. It is another very important term just like volts, amperes, etc.

Feel free to experiment with this receiver. You need have no fear of getting "shocked" as the voltages used are very low. Do not "short circuit" the "B" battery, for that will ruin it. By short circuit is meant the connecting of a wire directly from the positive to the negative terminal. This would drain all of the electricity from the battery in a very short time. So be careful that no piece of wire accidentally falls across the battery. Also watch that you do not connect the "B" battery to the heater of the tube, as this would "burn out" the heater of the tube. It would no longer get hot.

Some interesting experiments to try are as follows:

1 - Try reversing the positive and negative of the "B" battery in the plate circuit.

2 - Touch your finger to the grid terminal of the tube while the set is playing.

3 - Try grid resistors of various sizes, such as 2 megohms, 1 megohm, and other size that you might have handy.

4 - Turn the heater voltage off while the set is playing.

5 - Experiment with different size tuning and aerial coils.

As was mentioned previously, the tube, as used in this circuit, does not amplify. As a result the signals heard on this receiver will not be a great deal louder than those heard on the crystal set. However, you will be using a tube with its controlling action, and the sound in the headphones will be coming from the power of the "B" battery. A great deal can be learned by experimenting with this simple tube circuit.

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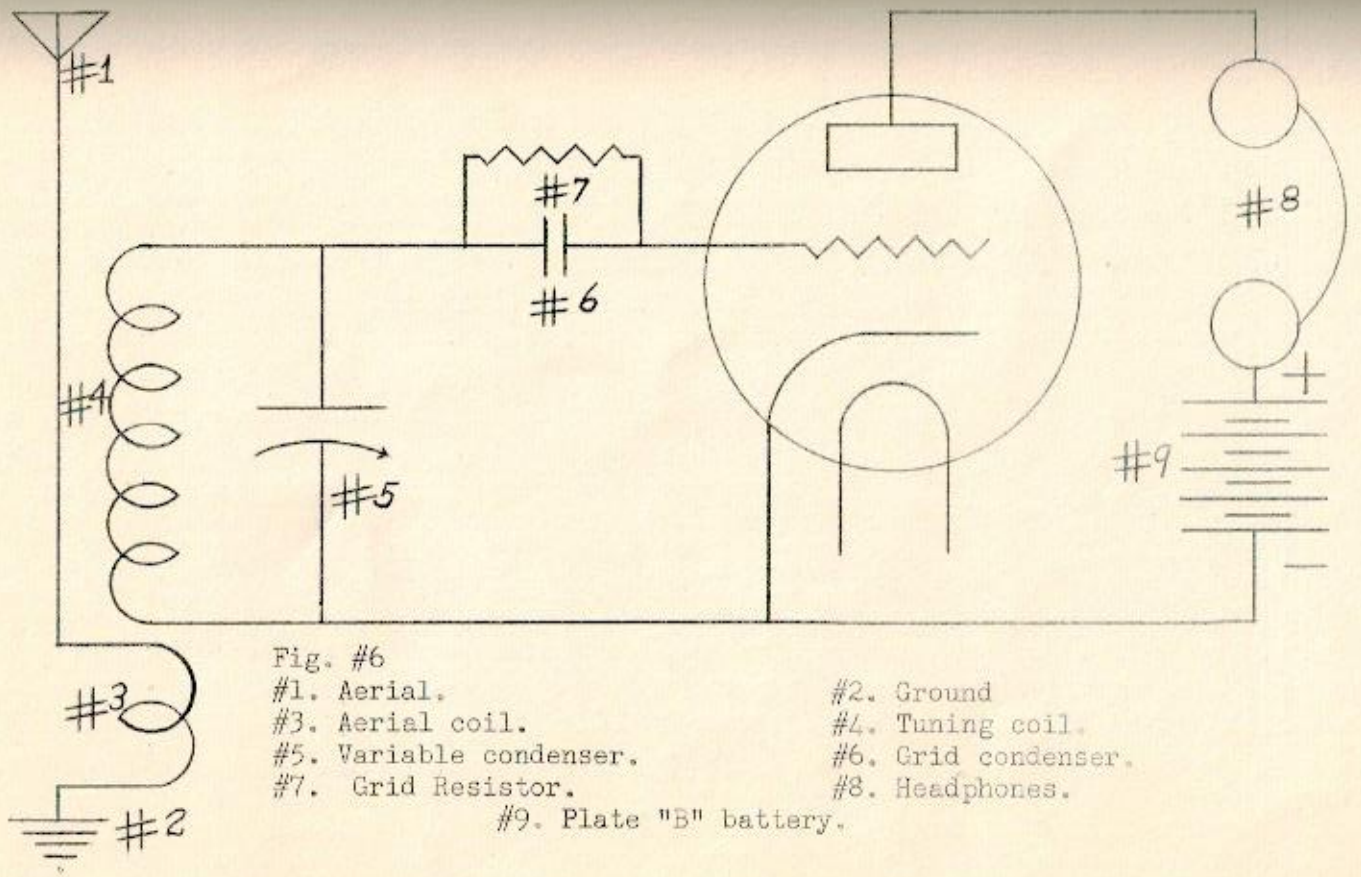

Fig. #6
#1. Aerial.
#2. Ground
#3. Aerial coil.
#4. Tuning coil.
#5. Variable condenser.
#6. Grid condenser.
#7. Grid Resistor.
#8. Headphones.
#9. Plate "B" battery.

circuit.

CHAPTER XI - A REGENERATIVE ONE TUBE RECEIVER

By simply adding a few more parts to the one tube receiver, just described, we can greatly improve its performance; get much better reception. We are going to give the tube a chance to amplify, as well as detect.

The diagram, with these additional parts, is shown in Fig. #7. Of course the circuit is somewhat more complicated but it is a fine one to experiment with, and if you get it to working the very best, it will receive stations a thousand miles or more distant. It has much better selectivity; it has a great deal more volume.

Careful inspection of the diagram will show that ALL of the changes have been made in the plate circuit. The aerial circuit is the same; the tuning grid circuit is the same; but in the plate circuit, we have added four parts; two coils and two condensers. The plate of the tube is now connected through the two coils before it connects to the phones.

Now in our plate circuit there are several kinds of electricity. First, there is the steady direct current furnished by the plate circuit "B" Battery; then there is the vibrating direct current representing the sounds which the headphones reproduce; and then there is the radio frequency carrier wave from which the sound has been separated by the detector tube. Now it is this radio frequency current, which is in the plate circuit, that is of special interest and use to us at this time. It is just the same as came in on the aerial but slightly amplified by the tube action.

Now you will notice that the plate current is made to flow first through a coil which is placed close to the tuning grid circuit; just as the aerial coil is placed near the tuning circuit. This coil is called the "tickler" coil. Now why shouldn't the radio frequency current in the plate circuit feed right back into the grid circuit and go through the tube for some further amplification? Well, that is exactly what happens.

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Careful inspection of the diagram will show that ALL of the changes have been made in the plate circuit. The aerial circuit is the same; the tuning grid circuit is the same; but in the plate circuit, we have added four parts; two coils and two condensers. The plate of the tube is now connected through the two coils before it connects to the phones.

Now in our plate circuit there are several kinds of electricity. First, there is the steady direct current furnished by the plate circuit "B" Battery; then there is the vibrating direct current representing the sounds which the headphones reproduce; and then there is the radio frequency carrier wave from which the sound has been separated by the detector tube. Now it is this radio frequency current, which is in the plate circuit, that is of special interest and use to us at this time. It is just the same as came in on the aerial but slight amplified by the tube section.

Now you will notice that the plate current is made to flow first through a coil which is placed close to the tuning grid circuit; just as the aerial coil is placed near the tuning circuit. This coil is called the "tickler" coil. Now why shouldn't the radio frequency current in the plate circuit feed right back into the grid circuit and go through the tube for some further amplification? Well, that is exactly what happens.

We feed the r.f. in the plate circuit back into the grid circuit; you might say it goes "round and round," always getting louder. This is called "feedback" or "regeneration" in a radio circuit and can be used to produce tremendous amplification. Of course the signal from the aerial starts the processing going, and you may ask why the signal doesn't get "all tangled up" in the process. However, you must keep in mind that all this electrical movement is of such high speed that it is practically instantaneous. So you see the tickler coil in the plate circuit, is used to sort of "tickle" the grid circuit.

Now this feedback action must be under control. If there is too much feedback, the tube will become an "oscillator" or generator of radio frequency current, and we will hear a bunch of "whistles," "birdies," or "howls" as we tune around. If we don t have enough feedback, then, of course, we wont get the maximum amount of amplification that is possible. So you see there is a definite amount of feedback necessary for best results. So in our regenerative circuit we must have a means of controlling the feedback. The remaining three parts, that is the #9 coil, the #10 variable condenser, the #11 fixed condenser, all are used for this purpose. The #10 condenser is the actual feedback control.

These parts are used to separate the r.f. current from the sound current after they have gone through the tickler coil. After leaving the tickler, each must follow its own path, or circuit, back to the cathode. The r.f flows through the #10 variable condenser, back to cathode, thus completing the r.f. loop. The sound current, called "audio frequency" current, or A.F., flows through the #9 coil to the phones, completing its loop to the cathode through the "B" battery. Condenser #11 is used to "bypass," or keep out, any r.f. that might get into the audio circuit. Coil #9 is called a "radio frequency choke" because it tends to "choke" or hold back any r.f. that might want to pass through it to the phones. With this r.f. choke in the circuit, the r.f. current has but one path to follow and that is through the variable condenser #10. The more its plates are closed, the more easily the r.f. can "jump" its plates and complete the

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loop to the cathode and thus increase the feedback. In this fashion the #10 variable condenser becomes the means of regulating the feedback.

In order to more clearly understand all of this, it is suggested that you put together this receiver and begin to experiment with it. You will find this circuit to be a lot more "tricky" than the previous model, but that s where the fun comes in. This receiver will have two adjustments for tuning; the #6 variable condenser for selecting the station; and the #10 variable condenser for controlling the feedback. Usually both of these must be adjusted when changing stations. They will tune quite sharply.

Again, the exact placing of the parts is not especially critical, although the parts should be mounted close together so as to keep the connecting wires short. The parts, especially the variable condensers, should be mounted or fastened securely to the board on which the parts are placed. A board 9 by 12 inches in size should be large enough for all the parts. A suggested arrangement of the parts is as follows: Mount #6 tuning condenser on the front lefthand corner. Mount #10 feedback condenser on the front righthand corner. Mount coils #3, #4, #5, in back of #6 condenser. Mount tube socket in about the middle of the board, with the heater connections toward the right hand side. The grid condenser and resistor should be placed near the grid terminal of the tube socket. The r.f. choke #9 should be mounted somewhat to the right and rear of the tube. The bypass condenser #11 can be placed near the righthand end of the board and the "binding posts" or connections from the phones and "B" battery can be placed on the righthand edge also. You will notice from the diagram that the rotor plates, or frame of the variable condensers, are connected by a wire. This should be a straight wire going directly from the one condenser to the other. In some cases it may be found advantageous to "ground" this wire; that is connect a wire from it to the ground end of the aerial coil.

Now as to the coils #3, #4, #5. They must all be wound on one form; #4 is in the center with #3 to one

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Now as to the coils #3, #4, #5. They must all be wound on one form; #4 is in the center with #3 to one

end and #5 to the other end. #3 might be 10 turns; #4, 40 turns; #5, 15 turns; all wound in the same direction. Such coils, already wound, can be purchased at very reasonable prices. They are called "plug-in" coils, because they are wound on a form something like a tube base. The form has connection pins, just like a tube, and plugs into a regular tube socket. The ends of the coil windings are connected to the pins in the base of the form. By this arrangement, coils of various sizes can be plugged into the circuit, thus giving various tuning ranges. A set of 4 or 5 such coils can be purchased to cover the broadcast band and all the popular short wave bands. The Hammarlund XP-53 coils are very satisfactory for this purpose. Having 3 windings, these coils will, of course, have a 6 pin base and require a 6 prong socket for mounting.

The tuning condenser #6 may be the ordinary 23 plate, .0005 mfd size, although much smoother tuning will be obtained with a smaller condenser, such as a .00015 mfd "midget" condenser. This .00015 mfd is often called 150 mmfd. The feedback condenser #10 may be of the larger 23 plate size; it is not critical. The grid condenser is .00025 mfd; the grid resistor is 5 megohms. The bypass condenser #11 is a fixed condenser of .001 mfd. The r.f. choke #9, which consists of a large number of turns of fine wire wound on a pencil-shaped stick, is of 10 mh size. The exact size is not critical. It, as well as any of the other above mentioned parts, can be found in a radio parts catalog, and purchased from a radio parts store; that is, if you can't find them in old radios.

Now as to the operation of this receiver. If it is working properly, closing the plates of the feedback condenser all the way will cause the set to "oscillate." As the plates are closed a "thump" will be heard, indicating that the tube has started to oscillate. Also "whistles" will be heard as the tuning condenser is rotated. The set MUST operate in this fashion; otherwise the feedback action is not working properly. The receiver is most sensitive to weak signals JUST BEFORE the feedback condenser starts the tube oscillating; just before the "thump."

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If the receiver will not oscillate in this fashion, and turning the feedback condenser seems to make no difference, then any, or all, of the following troubles may be the cause.

1. It may be necessary to reverse the two connections to the tickler coil #5. Connected one way, the tube will oscillate; connected the other way, it will not.

2. It may be necessary to use a shorter aerial. Try about 10 feet of wire stretched inside the room as an aerial.

3. It may be necessary to use a 45 volt "B" battery in the plate circuit instead of the 22.5 volt battery.

4. Try a different tube. Also a different size grid resistor.

So you see there is great room for experiment with this one tube regenerative receiver. Many things can be tried and the better you get to understand it, the better results you will obtain. The receiver should "go into oscillation" smoothly, and not with a hard "thump," and to get this requires a lot of patient experimenting. If the tuning of the receiver is seriously disturbed by the presence of your hands, you can place an aluminum metal panel on the front of the receiver to "shield" the hands from the coils, condensers, etc. You will notice that placing the hand near the coil, will greatly disturb the tuning. This metal panel should be grounded.

So try your luck. You have now advanced to the study of a very interesting circuit and of very vital parts in modern radio and when you master them you will have a good "foothold" in the understanding of the technical side of radio.

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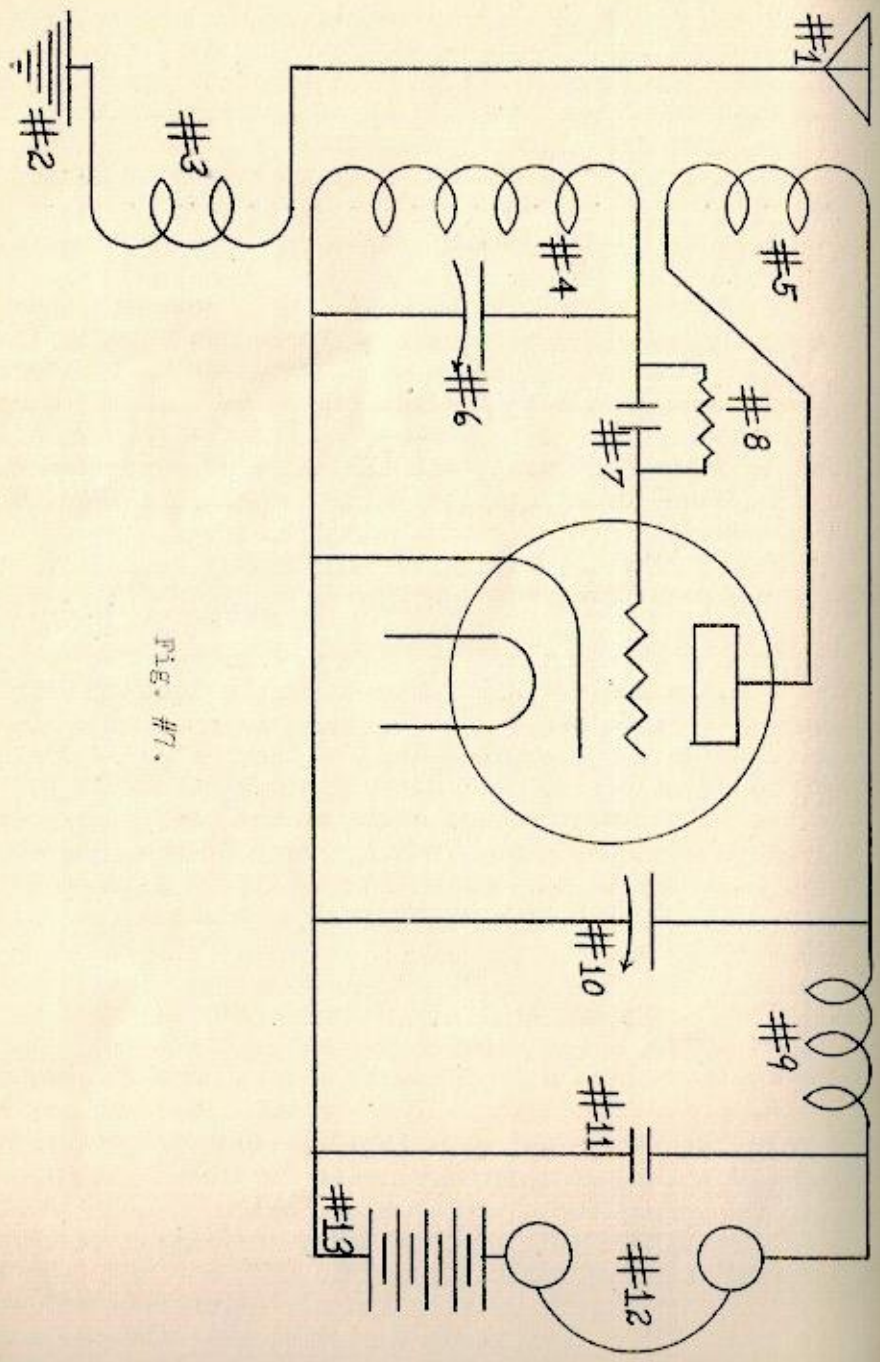

FIG. #7.

CHAPTER XII - MORE TO STUDY

This final chapter will be devoted to brief discussions and descriptions of a few other developments vital to modern radio. Each of these can be given much detailed study, if you wish to follow this work further.

RADIO TUBES

We have studied one type of tube. However, there are more than 150 other types of tubes now in general use. The five pin tube, used in our experiments, has a maximum amplification of about ten times. On the other hand, tubes, especially of the "screen grid" type, have been developed having an amplification of more than 200 times. Such screen grid tubes can usually be identified by the metal "cap" or connection coming out through the top of the glass. Such "high-gain" tubes naturally make for very sensitive receivers.

Then there is the large group of tubes, called "power tubes," which are used to develop the sound or "audio" power to operate high-powered "dynamic" speakers. You see, in order to reproduce the low base notes of music, such as of an organ, considerable power is needed to vibrate the speaker. Most small radios have a power of 3 watts for the speaker, although many of the finer-toned instruments have anywhere from 15 to 25 watts of power. The "power tubes" are used to develop this "audio" power.

Then there are the "glass" tubes and the newer "metal" tubes. In the metal tubes the glass shell has been replaced by a metal shell; the internal elements remaining about the same. These metal tubes are smaller in size and can be built more easily into compact radios; they require no "shield" cans be placed about them. They do not necessarily give better results. All metal tubes fit a standard 8 prong "octal" socket. The 6c5 is a metal tube corresponding very closely to the tube we used in our experiments. It has the heater, cathode, plate, and control grid, and, in addition, the metal

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shell is connected to a pin. This metal shell may be grounded to advantage. Of course the heater is the 6.3 volt type; the numeral six of the 6c5, meaning the heater voltage.

Then there are the very large "transmitting" type of tubes. These are much larger in size than the receiving types, and are used to generate the radio frequency power used for transmitting purposes. Such tubes use very high voltages for the plate circuit; anywhere from 400 to 3000 or more volts being in general use. The performance of these tubes on the short wave bands has been greatly improved in recent years.

AERIAL AND GROUND

Almost any sort of a piece of wire, hung up almost anywhere, will pick up radio signals; but such aerials do not always give the best results obtainable. The most important thing is to stretch the aerial "in the clear;" that is out in the back yard, away from building, trees, and other wires, insofar as this is possible. You see, this gives the aerial a better chance to pick up the signals. Also it is desirable to hang the aerial as high above ground as practical; 30 to 40 feet high being very fine. The aerial can be all of one piece, bringing the end of the aerial wire right into the "radio room;" a total length of 100 feet being very satisfactory.

Stretching the aerial under the metal gutters of the house, or over a "tin" roof, is a very poor arrangement. You would do much better to hang your aerial from a second floor window to the top of a wash post. If the aerial wire should have a tendency to touch any part of the building or other objects in its path, it will be a good idea to "insulate" it from these objects by using "nail-knob" or "screw-eye" insulators. The aerial may be brought through the window by the use of a "lead-in" strip; a very thin piece of metal which can be placed under the window, even when it is closed.

Other special types of aerials are being developed.

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It is the purpose of these aerials to pick up the signals, but NOT to pick up the electrical interference caused by electric sweepers, electric razors, etc. Such aerials are called "doublet" aerials or "short Wave" aerials. Under favorable circumstances they represent an improvement, but for our experiments, such aerials are not necessary or even desirable.

The ground connection is simply a wire securely fastened to a water pipe or a radiator pipe, or a six foot pipe driven into the ground. Gas pipes should not be used. Usually #14 rubber covered wire is used for the ground connection, although this is not critical. The connection can be made to the pipe by the use of a "ground clamp." Of course the paint or rust should be scraped from the pipe before the connection is made, so as to obtain a good electrical connection.

POWER SUPPLIES

In our experiments we have used a plate circuit battery to provide pure direct current for the plate of the tube. However, in large receivers, where 300 volts or more are needed for the proper operation of the tubes, batteries are too costly and bulky to be used; in fact they are just a nuisance. And so we substitute a POWER SUPPLY for the batteries. The power supply is connected to our regular 110 volt 60 cycle alternating house current. It operates from this power but changes the alternating current to pure, steady direct current, with no trace of "ripple" or "hum." Also the power supply will change the voltage from 110 to whatever figure is required; to 3000 volts for the large transmitting tubes, if need be. You see, the power supply is a very useful piece of radio equipment. Its cost of construction is low and the electricity, used in its operation, is inexpensive. A power supply consists of five main parts as follows:

1. A power transformer for changing the voltages.
2. A "Rectifier" tube, used to change the alternating current to pulsating direct current.

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1. A power transformer for changing the voltage
2. A "rectifier" tube, used to change the alternating current to pulsating direct current

3. Iron core "filter chokes," used to smooth out the pulsating, humming current.
4. "Filter Condensers," used to smooth out the pulsating humming current.
5. A "bleeder resistor," to distribute the power and regulate the voltages.

Also the power supply will furnish all of the low voltage alternating current used to heat the heaters of the various tubes in the receiver or transmitter. In this way our equipment is operated entirely from the house current with no need for batteries.

THE SUPERHETERODYNE RECEIVER

Most modern receivers are of the "superheterodyne" type. These receivers use a far more selective tuning system and, of course, they are able to select stations in a most marvelous fashion. Instead of using one tuning circuit, as was the case with our one tube regenerative receiver, these receivers use anywhere from 6 to 10, or more, tuning circuits; all functioning simultaneously. Of course, such a tuning system, together with all the tubes used with it for amplification purposes, is quite complicated; but of such ingenuity are our fine modern radios made.

While on the subject of superheterodynes, it will be well to mention another fine development and that is "Automatic Volume Control." By using this ingenious circuit arrangement, the signal coming in on the aerial is used to control the amplification of the tubes in the receiver. As soon as we tune into a strong local station, the amplification of the tubes is almost instantly and automatically cut down to the proper amount. This prevents "blasting" and loud, noisy tuning and reduces fading and static noises. As soon as we tune off of a station, the full power of the receiver is automatically turned on, in order to pick up the weakest sort of distant station. Under these conditions, considerable "static-noise" may be picked up and some persons dislike these receivers because they feel that they are "noisy." However, once you get the knack of

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operating such a receiver, with automatic volume control you will want no other type.

AMATEUR RADIO

Now here indeed is a modern, educational, fascinating hobby, if ever there was one. "Amateur Radio" refers to those persons who have experimental receivers and TRANSMITTERS set up in their homes to be used in communicating with other amateur stations throughout the country and even throughout the world. And indeed it is some "thrill" to sit before your own microphone or telegraph key and talk to some brother amateur hundreds or thousands of miles away.

To "be on the air" and enjoy such Amateur Radio privileges, it is necessary to obtain a station and operator s license from the Federal Government. The Amateur laws and regulations vary in the various countries of the world, but in the United States Amateur Radio is especially encouraged by the Government. Approximately fifty thousand operators and stations are licensed in the United States. Of course these amateur stations are licensed for experimental and amateur use only. In other words, it is not permissible to give lectures, broadcast music, or in any way attempt to entertain the public with such stations. Also such stations cannot be used for any commercial, or financial purposes whatsoever. In the United States you are privileged to send radio messages to or for any of your friends, anywhere in the country but you cannot accept compensation of any sort for doing it. It must be purely a hobby; purely "for the fun of it." However, do not get the idea from this that there is nothing left for the Radio Amateur to do. Making hundreds of new friends over the air, friends who have the same hobby as yourself, is a most unusual pleasure and opportunity. And there is nothing formal about these friendships. You just say, "hello how are you?" "How are you doing up there in Pittsburgh, anyway?" The educational possibilities of Amateur Radio are most excellent. By experimenting with this apparatus you are certain to

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AMATEUR RADIO

Now here indeed is a modern, educational, fascinating hobby, if ever there was one. "Amateur Radio" refers to those persons who have experimental receivers and TRANSMITERS set up in their homes to be used in communicating with other amateur stations throughout the country and even throughout the world. And indeed it is some "thrill" to sit before your own microphone or telegraph key and talk to some brother amateur hundreds or thousands of miles away.

To "be on the air" and enjoy such Amateur Radio privileges, it is necessary to obtain a station and operator's license from the Federal Government. The Amateur laws and regulations vary in the various countries of the world, but in the United States Amateur Radio is especially encouraged by the Government. Approximately fifty thousand operators and stations are licensed in the United Statins. Of course those amateur stations are licensed for experimental and amateur use only. In other words, it is not permissible to give lectures, broadcast music, or in any way attempt to entertain the public with such stations. Also such stations cannot be used for any commercial, or financial purposes whatsoever. In the United States you are privileged to send radio messages to or for any of your friends, anywhere in the country but you cannot accept compensation of any sort for doing it. It must be purely a hobby; purely "for the fun of it." However, do not get the idea from this that there is nothing left for the Radio Amateur to do. Making hundreds of new friends over the air, friends who have the same hobby as yourself, is a most unusual pleasure and opportunity. And this is nothing forma about these friendships. You just say, "Hello how are you" "How are you doing up there in Pittburgh, anyway?" The educational possibilities of Amateur Radio are most excellent. By experimenting with this apparatus you are certain to

learn a great deal of the technical side of radio. Most of our professional radio operators have "graduated" from the school of amateur radio, and many of them stay with it as a recreation even after that.

To obtain an amateur license in the United States, mainly two things are necessary. You must learn to receive and transmit the International Morse Code at a speed of 13, five letter, words per minute. Also, you must learn something of the elementary, technical features of amateur receiving and transmitting equipment. This is in order that you may answer ten written questions given to you at the time of your examination. Also, it should be noted here that in the United States, only citizens can obtain amateur privileges.

The American Radio Relay League, West Hartford, Conn., is the official organization for amateur radio activities in the United States. They publish QST, a monthly magazine devoted entirely to amateur radio, describing new technical developments; giving operating news, etc. Also they publish yearly the "Radio Amateur's Handbook;" a complete technical work on the subject. Also they publish the "Radio Amateur's License Manual," giving all the questions and answers which may be asked at the amateur examination. These two books are now available for the blind, in braille, having been transcribed by the American Red Cross and the Library of Congress.

If you want a fascinating hobby, that might lead to work in this very modern radio field, then try your luck at Amateur Radio, and the best of luck to you.

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