SCIENTIFIC EXPLORER™

CRYSTAL RADIO™

8+

Make Your Own Real **WORKING RADIO** Without Batteries!

⚠ WARNING:
CHOKING HAZARD - Small Parts.
Not for Children under 3 years.

WHAT'S IN YOUR KIT

You will also need the following things:

- pencil
- 4 thick books
- scissors or wire cutters
- magnifying glass
- small screwdriver

WARNING:
This radio works without any electrical source. It must not be connected to any electrical appliances or to an electric outlet. Beware of sharp points and rough edges.

BUILDING THE RADIO

Getting Started

A. Listen to the Earphone

Before putting the crystal radio together, you should examine two of its parts, the ***earphone*** and the ***diode.***

The earphone is one of the most important parts of your crystal radio. It is the earphone that changes electrical impulses into sound. Any small electrical impulse will make the earphone click.
Many common things contain a tiny electric charge.

Put the earphone to your ear. Hold one bare wire end in your hand. Touch the other bare wire end to things around the house: a water faucet, a metal window frame, or a radiator.

> **WARNING:**
> Do not touch the wire to a wall socket, or to a lamp outlet, or to anything that carries electricity.

B. The Crystal Diode

The heart of your crystal radio, the part that contains the crystal, is the diode. Be very careful when you open the package that contains your crystal diode! Diodes are made of glass and can break.

A diode is an electrical device that lets current pass only one way. The reason that this is important is a complicated one. You will learn more about it later, in the section called “How Radio Works”.

If you have a magnifying glass, take a close look at the diode with it. Inside the glass tube is a tiny speck, a crystal of germanium, one of the rarest metals in the world. Pressing against it is very fine wire. Can you see the crystal and the wire? (See Fig. 1)

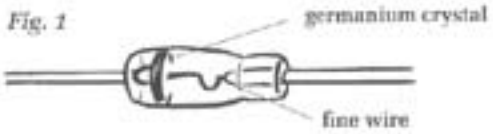


Fig. 1

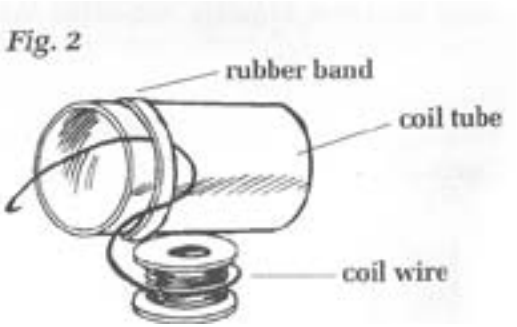
Building the Radio

A. Prepare the Tuning Coil

1. The first step in building the crystal radio is winding the tuning coil. Start with the spool of wire. Take the tape off it, and find the end of the wire.

2. Slide a rubber band over one end of your coil tube. Slide it down about 1/2 in. from the end of the tube. (Fig. 2)

Fig. 2

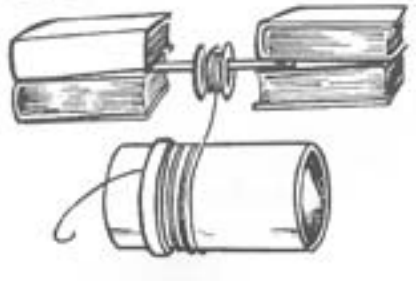


B. Wind the Coil

Note: Adult help is advisable for this task. Winding the coil must be done very carefully and precisely, or your radio will not work.

1. Slip the spool of wire onto a pencil. Rest the two ends of the pencil on two thick books. Then put two more books on top of the pencils to hold them in place. The spool can now turn freely on the pencil. (Fig. 3)

Fig. 3



2. Hold the end of the coil tube loosely in one hand, with your thumb over the coil wire.

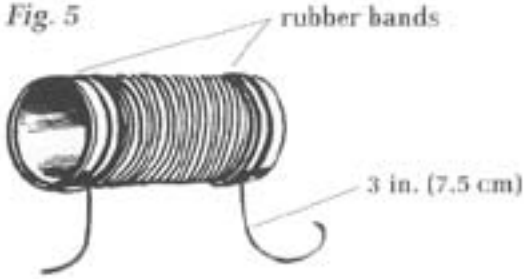
Now **turn the coil tube** with your other hand. Keep your thumb resting on top of the wire, guiding the wire so that it lies smooth and flat on the coil tube. The wire must be wound so that it is only one layer thick, with the wires lying snugly side by side. The wires

should touch, but **they should never cross or overlap one another.** (Fig. 4)

Fig. 4

3. When you come to the end of the wire, finish up so that the wire at the beginning of the coil and the wire at the end of the coil are on the same side of the coil tube. Be sure you have at least 3 inches sticking out over the end of the tube. (Fig. 5)

Fig. 5



4. Slip another rubber band over the tube and wire to hold the end of the wire in place. Make sure your coils are neat and tight, and put the tuning coil aside.

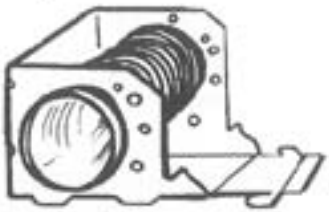
C. Prepare the Base and Insert the Coil

1. Place the plastic base face down, so that you don't see the printed letters and words. Bend up the square back panel and bend in the two tabs.

2. Now bend up the two side panels. If there are circles of plastic in the side panels, just push them out and throw them away.

3. Bend in the tabs on the side panels. Push them into the slits in the tabs of the back panel. Make sure that the tabs lock securely in place. Don't bend the front panel up yet.

Fig. 6



4. Slip one end of the coil into one side of the base. Slip the other end into the other side of the base.

5. Turn the coil so that the ends of the coil wire are next to **Hole D** on one side of the base and **Hole B** on the other. (Fig. 6)

Slip one wire through **Hole B**. Wind this end around and through **Hole B** twice and cut it off.

6. Slip the other wire through **Hole D** on the other side of the base. But **DON'T** cut it off.

7. Your coil wire is covered with a film of thin, clear plastic insulating material. Electricity cannot get through it. You have to clean this film off the end of the coil wire that goes through **Hole D**. Here's how:

A. Fold your piece of sandpaper, sand side in.
B. Put about 1 inch of the end of the coil wire in **Hole D** into the folded sandpaper.
C. Squeeze the sandpaper and pull the end of the wire out of the fold. Do this at least 10 times. Keep turning the wire. Sand off the insulation all the way around.

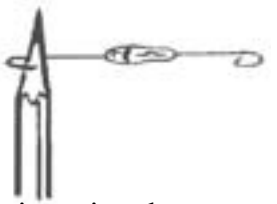
Save your sandpaper. You're going to use it again later.

D. Prepare the Earphone, the Diode, and the Connecting Wires

1. Unwind the 2 wires that are twisted together on your earphone, so that each wire end is approximately 6 in. long. Tie a simple knot in the wire so that the wire does not unwind any more.

2. Make a small loop at the end of each diode wire by bending the wire around the lead of a pencil. (Fig. 7) The loops should be able to slip over the end of one of the bolts supplied with your kit.

Fig. 7



3. Make a small loop at one end of each connecting wire, the same way you did with the diode.

E. Put the Earphone and Tuning Rod onto the Base

1. Put one earphone wire into **Hole D** and out again through **Hole C**.

2. Do the same with the other earphone wire on the other side of the base. Put it in **Hole B** and out **Hole A**.

3. Make a small loop at the end of each earphone wire around the lead of a pencil.

4. Push the tuning rod into **Hole 1**. Push the rod in a little way and slip the tuning ball onto it. Then push the rod all the way through until the rod goes through **Hole 2.**

5. Turn the tuning rod so that the eye lines up with **Hole 4**. Your radio should look like the drawings in **Fig. 8a & b.**

Fig. 8a
Left side

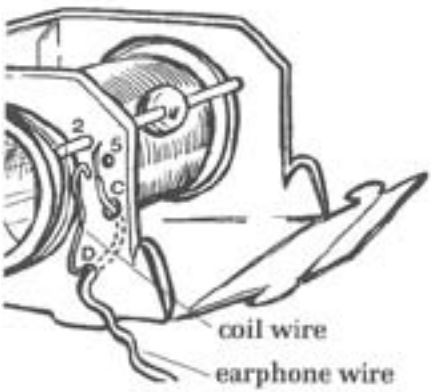
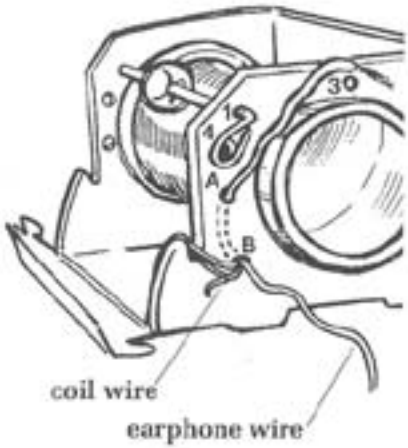


Fig. 8b
Right side



F. Make Connections
Now you are ready to make connections.

1. Put the end of one connecting wire <u>without</u> the loop in through **Hole D** and out again through **Hole C**.

2. Prepare a bolt by slipping a washer onto it. Then slip the loops of the following wires onto the bolt:
   -the connecting wire
   -the nearest earphone wire
   -the coil wire

3. Slip on the second washer, and put the bolt into **Hole 5.**

All this stuff can get confusing. Work slowly and carefully. You'll get it right!

4. Hold the bolt tightly against the base. With your other hand, put a nut onto the bolt and screw it on loosely. This is the ***ground ("earth") connection.*** Check to make sure that all wires are clamped between the two washers.

5. Thread the second connecting wire in through **Hole B** and out again through **Hole A**. Slip a washer on another bolt. Then slip on the loops of:

- the other connecting wire
- a diode wire

6. Slip on the second washer and put the bolt through the eye of the tuning rod and into **Hole 4**. Put on a nut and screw it on loosely as before. This is your ***antenna connection.***

7. Put a washer on another bolt, and slip on the loops of:

- the diode wire
- the remaining earphone wire

Put on a second washer. Push the bolt into **Hole 3**, and screw on the nut.

8. Now tighten all your connections by screwing on the nuts as tightly as possible. Your drawings should look like the ones in **Fig 9a & b.**

Fig. 9a
Left side

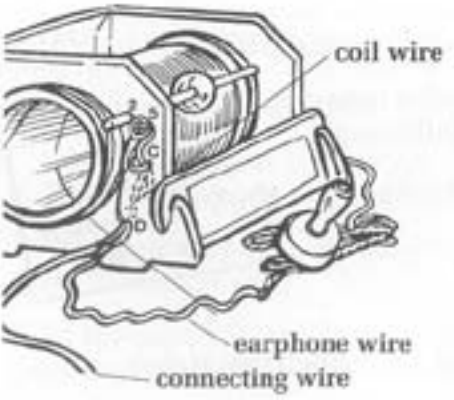
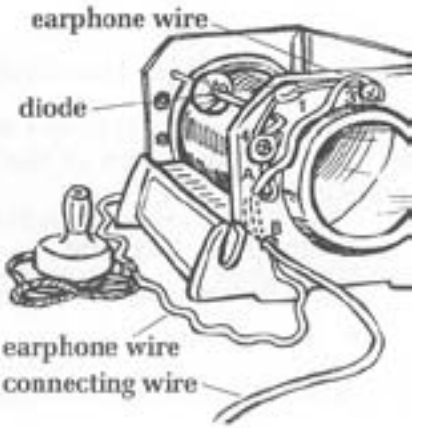


Fig. 9b
Right side



G. Check Your Connections and Close Up the Base

1. Check your connections:

Left Side: **Hole 2**: the straight end of the tuning rod

Hole 5: a connecting wire
an earphone wire

Right Side: **Hole 1**: the tuning rod

Hole 3: a diode wire
an earphone wire

Hole 4: the eye of the tuning rod
a connecting wire
a diode wire

Yes!! If you check out OK on these you're almost done!

Remember, all connections have to be made correctly on bare wire and securely tightened or the radio will not work.

2. Close the base. Fold the front panel towards the coil and slide the tabs on each side into the slots near **Holes D** and **B.**

H. Sand the Tuning Coil

The tuning ball must make contact with bare wire on the tuning coil. But your coil wire is still covered with a clear plastic coating. The entire length of the coil under the rod must have the insulation sanded off. Here's how to do it:

1. Run the tuning ball back and forth a couple of times so it makes a light mark along the top of the coil. Then turn the coil tube just a little so that the mark moves out from under the rod.

2. Sand gently along the mark until the insulation there is removed. Then roll the tube back so that the sanded area is under the tuning rod again.

Remember, if the ball doesn't make contact with bare wire, your radio won't work.

Your crystal radio is now ready!

I. Listen to the Radio

Take your radio to a cold water faucet. Touch the faucet with a connecting wire, and hold the bare end of the other wire in your hand. (To make it easier, attach the bare part of the first wire to the tap with a rubber band).
Now put the earphone in your ear. Start moving the tuning ball slowly until you pick up one or more stations.
The sound will not be loud. A crystal radio does not have the power that a regular radio has. It lacks an amplifier. But if the reception in your area is good, you should be able to pick up more than one station.

EXPERIMENTS WITH YOUR RADIO

1. Experimenting with Different Antennas
A crystal radio works well only if you have a good antenna (aerial) to receive the radio waves. The farther you live from a radio station, the better the antenna must be. A cold water tap makes a good antenna. This is why you attached one of the wires to the water faucet. You used the faucet as an antenna.

Now try other things. Take the wires off the faucet. Touch the wire to different items: a drainpipe, a door, a wall, a water pipe, a metal window frame, and a wooden table. ***DO NOT TOUCH ELECTRICAL WALL OUTLETS OR LAMP SOCKETS. DO NOT TOUCH ANYTHING THAT CARRIES ELECTRICITY.***

Outside you might try metal railings, a tree, a car antenna, a concrete wall, metal flagpoles. Remember: make sure that when you touch something with the wire, you hold the other wire in your hand.

Listen each time. Which items make good antennas?

-Try other things around the house. What material gives you the best results? Wood? Plastic? Glass? Metal?

- What size antenna gives you best results: something big, something long or something small?

2. Experimenting with Different Grounds
You can improve the reception of your crystal radio even more by connecting it to a ***ground*** (earth)-any piece of metal that leads to the earth. The ground (earth) for a crystal radio acts just like another antenna (aerial). A water pipe or a radiator will make a good ground. As before, remember to hold the bare end of the other wire in your hand.
Try combining different antennas and grounds. Do you get different stations? Try switching the antenna and the ground wires to see which brings in the louder sound.

3. Identifying Stations
By now you should have tried several different combinations of antennas (aerials) and grounds (earths). Now choose a good location, and try to identify the different stations you can pick up. There are two ways to do this:

1. Listen until the station announcer identifies the station.
2. Try to get the same station on a regular portable radio.

4. Identifying Stations Using Different Antennas
Try identifying different stations by connecting your radio to different antenna combinations. Do you pick up the same stations that you did before? Are all stations you pick up ones that you can identify? Crystal radios are peculiar devices. Sometimes you may pick up very distant stations, even broadcasts from another country!

5. Keeping a Record of Stations
You may want to keep a record-called a *log*-of the different stations that you hear. In your log you should note the date, the time of day, the call letters of the station, and the city where the station is located. You might also want to note what combination of antenna (aerial) and ground (earth) you were using, and the approximate position of

the tuning ball on the turning coil. Use the scale on the base for easy identification.

6. Trying the Radio at Night
Listen to your crystal radio several hours after dark. You may find that you receive different stations, especially ones that are far away.

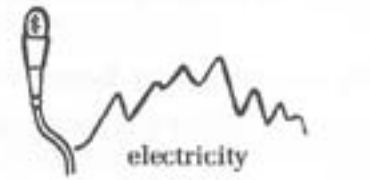
HOW RADIO WORKS

By now, you may be interested in knowing something about how your radio works. Let's start by taking a look at the radio station where the whole process starts.

Fig. 10a

In the sound studio of a radio station, a radio announcer is speaking into a microphone. ***Fig 10a*** is a simplified diagram of the announcer's speech. The peaks and valleys of the wavy line represent the loud and soft sounds of what is said.

Fig. 10b



The microphone takes these sounds and turns them into electrical impulses that exactly correspond to the pattern of the announcer's speech, illustrated by ***Fig.10b***. Loud sounds make for strong electrical impulses. Soft sounds make weaker impulses. A diagram of the strengths of the electrical impulses would match up with the sound diagram exactly.

Meanwhile, at the station's transmitter, an electrical device called an oscillator is producing another electric current. This current is AC-alternating current. An alternating current is a current that continually changes the direction of its flow in an electrical circuit. First it flows in one direction, then it reverses and flows in the opposite direction, then it reverses again, back and forth, many times a second. The AC produced by the oscillator alternates this way

about a million times a second. An electronics engineer would say it has a ***frequency*** of about a million cycles or a million Hertz. (A million Hertz is also called one MegaHertz).

Fig. 11

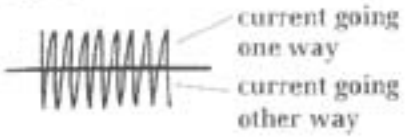


Fig.11 is one way of illustrating this alternating oscillator current.

At the station transmitter, the electrical impulses from the microphone are combined with the current from the oscillator. The result can be illustrated in Fig.12.

Fig. 12

Notice that the bottom half of the new current is a mirror image of the top half. In the top half of the diagram, the current is flowing one way; in the bottom half, it is flowing the other way.

A ***high-frequency*** current, that is, a current that alternates very rapidly, has a peculiar property: it gives off radio waves which have the same frequency as the current that produced them. Radio waves are somewhat like light: they spread through space at a speed of almost 200 thousand miles per second without needing any wires to carry them. Unlike light, however, radio waves are invisible, and they can travel through objects that would stop light-objects like trees, or buildings, or people.

Fig. 13

When the radio waves strike a long piece of wire, like the crystal radio antenna, they cause an electric current. This current is a very weak copy of the transmitter current that sent out the radio waves back at the station ***(see Fig.13)***

The alternating current set up in the crystal radio antenna travels to the diode. The diode is a one-way electrical switch. That is, it lets through electric current moving in one direction but blocks any current moving in the opposite direction. In effect, only the "top half" of the AC current gets through.

Fig. 14

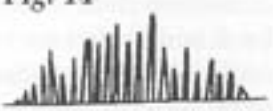


Fig. 15

From the diode, the modified current goes to the earphone, which turns it into a sound wave having the same shape as the sound impulses in the announcer's speech.

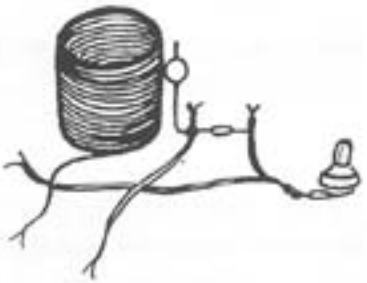
We hear the announcer at almost the same time she/he is speaking.

MORE ABOUT YOUR RADIO

The Circuit Diagram of the Radio

When you built your crystal radio, you made a number of moderately complicated mechanical connections. Several times, you passed two or three wires through different holes in the base and twisted them around various bolts. You probably gave very little thought to what the final connections look like as a whole.

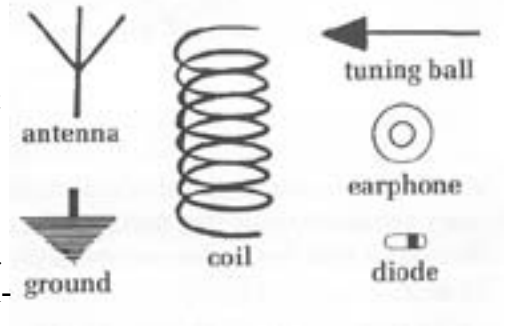
Fig. 16



But if you look at the top of your crystal radio and trace out the pathway of the metal wires and connections, you will find that it looks something like ***Fig. 16.***

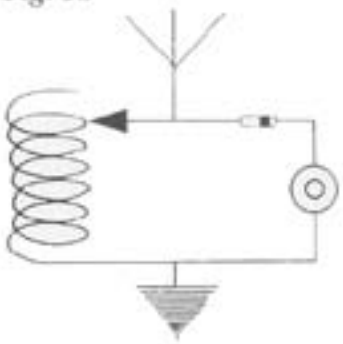
An electronics engineer would want a clearer diagram than this. The engineer would use the symbols shown in ***Fig. 17.***

Fig. 17



Using these symbols, he or she would produce a diagram that shows in the simplest way the pathways, or ***circuit***, that electricty can take in the radio. This kind of diagram, shown on ***Fig. 18***, is therefore called a circuit diagram.

Fig. 18



Compare this circuit diagram with the earlier sketch of the radio. Notice how much simpler the circuit diagram is. But notice how the circuit diagram shows the same essential information as the drawing.

- First, there is a pathway for electricty from the coil.
-Then there is an antenna (aerial) connected to the circuit between the tuning ball and the diode.
-And there is a ground (earth) wire connected between the coil and the earphone.

The Crystal Radio Compared to a Regular Radio

You may be interested in the similarities and differences between your crystal radio and a regular radio.

A regular radio has a power source-batteries or an electrical wall socket. It also has transistors in place of a single diode. The outside electrical power and the transistors work together to ***amplify*** (make stronger) the electrical impulses caused when radio waves strike the set's antenna.

This amplification permits a regular radio to pick up more stations with a much smaller antenna. The extra power also runs a loudspeaker instead of an earphone.

Another difference is the tuner of a regular radio, which allows FM broadcasts. FM is clearer, but AM signals travel farther. Your crystal radio picks up only AM.

Basically, your crystal radio and a regular radio work alike. The difference between the two make the regular radio more efficient.

No. 02012
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