THE PAPER-BOX CRYSTAL RADIO

Introduction

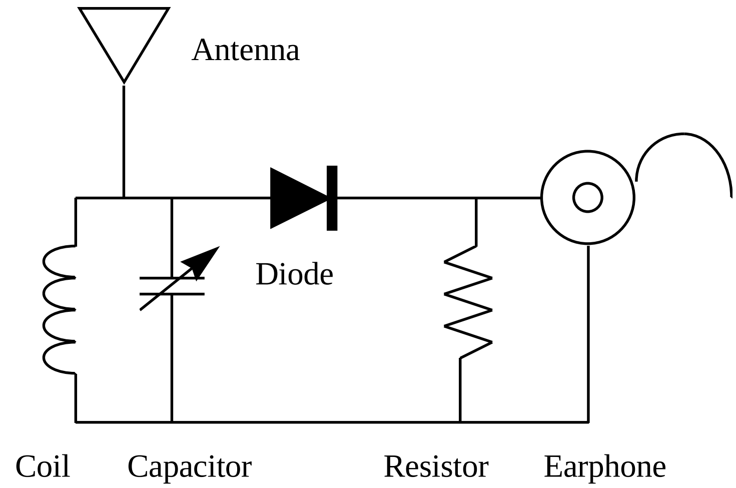
I wanted to demonstrate the beauty and elegance of Crystal Radios to a class of grade 2 and 3 students. I wanted to leave them with plans for a crystal radio that they could build under the supervision of their teacher. This crystal radio had to have the following characteristics:

1) It should require only readily available parts and be cheap. (Grade 3 teachers have enough to do without having to visit radio flea markets or to order expensive parts from other parts of the world).
2) It should be easy to assemble; specifically, it should not require dangerous or exotic tools (soldering irons fall into this category), and should not require high precision. "Fool proof".
3) It should work reasonably well. My goal was that it should be able to work in an urban area without an external antenna or ground.

This article documents the radio that I designed which meets all of the above criterion. Everything can be from local sources for under $10. It can be made with a knife (which should be used under supervision) and screwdriver. And, indeed, it picks up all four local stations (at 580, 1130, 1200, and 1310 kHz) with adequate "Q" to separate them.

The Design of the Paper Box Radio

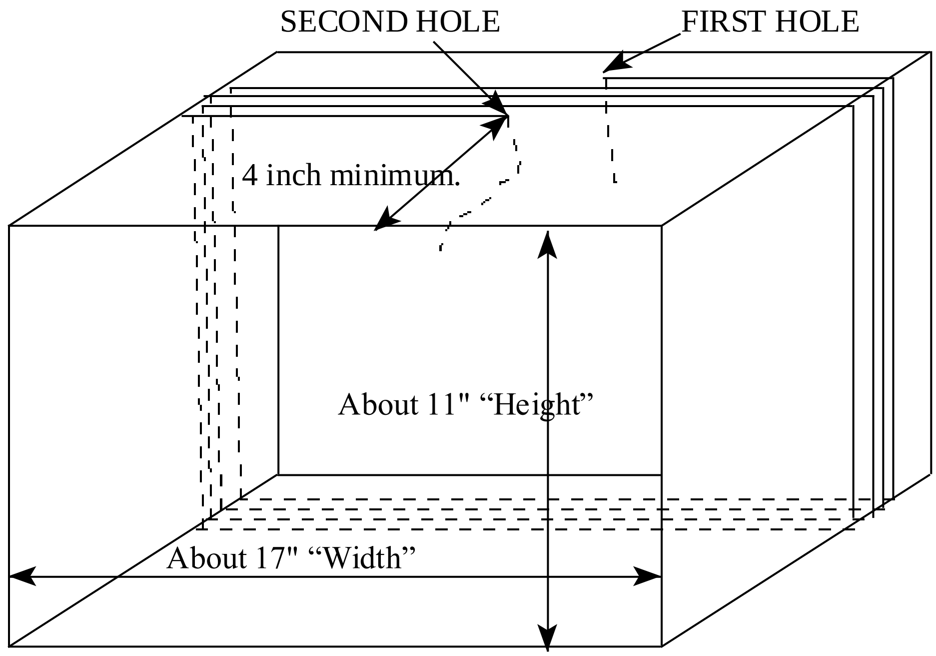
The schematic diagram for the radio is shown in Figure 1 and will be recognized by anyone familiar with crystal radios. The unique features of this radio are in the implementation of the inductor and capacitor.



Traditional crystal radios used inductors wound with enameled wire often with a slider to make the inductance variable. These inductors are actually rather difficult to make neatly, and the sliding electrical contact is difficult to implement. This radio uses a large box (an orange box, or the box that photocopy paper is supplied in) as a coil form, which means fewer turns are required making it easier to fabricate. The large size of the coil allows it to serve as an antenna as well. In addition, the box forms a base for the rest of the radio to be fabricated upon.

As the inductor is fixed, the tuning must be accomplished with a variable capacitor. These used to be available from any electronics store, but are becoming rare. While *I* know where to find them cheaply, and how to remove them from unwanted AM radios, the typical grade 3 teacher does not. To get around this, I have designed a variable capacitor that can be made with easily obtainable parts. The design of the capacitor is unconventional, and (I think) unique and original. The capacitor is fabricated with two foil plates taped to a cardboard shipping tube. These form the two electrodes of the capacitor. A rigid plastic film is wrapped snugly around the tube and the foil. It can rotate freely over the tube. A third piece of foil is taped to the plastic. By rotating the plastic, the overlap between the third foil and the first two foils can be changed, thereby changing the capacitance. Notice that this variable capacitor does not require any sliding electrical contacts as the two capacitor plates are completely fixed. The third plate, which moves, does not require an electrical contact.

The rest of the radio is straight forward. For the detector, I use the ubiquitous 1N34A diode as they are stocked locally, and are much easier to operate than “roll your own” schemes. Crystal earphones are also available locally, and are used in this



radio. The resistor of about 100000 ohms is optional, it may be required if the crystal diode is not very leaky.

Construction

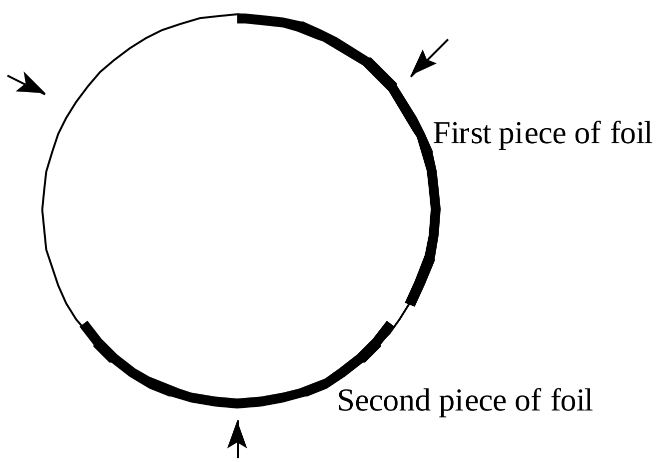
Select your box. The type that photocopier paper comes in is great. Oranges also come in this size of box. Size: 11" X 17" (dimensions of open side), with a depth of greater than 8". Wrap 11 turns of almost any type of wire around the 11" and 17" sides of the box.

Obtain a 3" diameter shipping tube. Neatly cut the shipping tube to a length to match the height of the box (11", or what ever height your box is). The ends should be "square". Cut another piece of shipping tube about 2-4" long. (This will become the "knob") Tape two pieces of aluminum foil onto the long tube, each the same length as the tube, and 2.75" wide. Be careful not to wrinkle the foil too much, and use only one layer of tape, but tape all four sides of the foil. The pieces of foil should not touch, but be about 0.5" apart or less. So, now about one third of the circumference of the tube will be covered with one plate of foil, another third will be covered with another plate, and the third third will be uncovered.

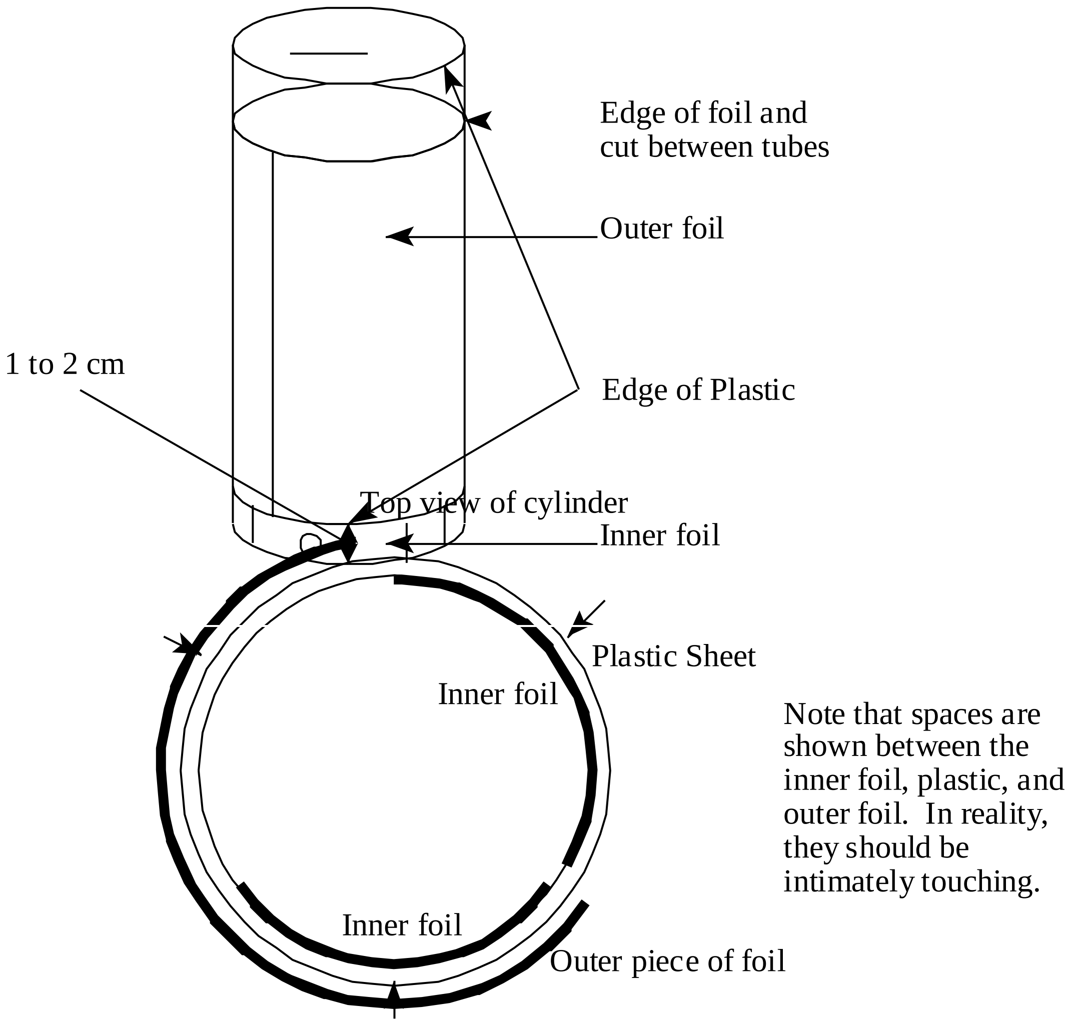
Now, obtain some appropriate plastic sheet. This should be the kind of film that does not stretch very much, and is not clingy. Food wrap (Syran wrap) is not suitable. The plastic liner used in cereal boxes, usually a white translucent film, is OK. The most reliable source is plastic sheet protectors used in three ring binders. The plastic needs to be about 16” by 11”. On the paper protectors, usually one 11” edge is folded and the other two edges are melted together. Carefully cut the melted edges off and unfold the plastic to produce a sheet of about the right size. It should be flat and wrinkle-free (except for the one fold down the middle).

Place the short tube next to the long tube. Wrap the plastic around the pair of tubes (the plastic should overlap with itself .5-2”), and tape it to itself (not to the tube). It should be tight against the tube, but you should be able to rotate it by twisting the part over the smaller length of tube. Rotate it around and make sure the foil underneath the tube does not tear. Position the plastic so that there is a .5-1” gap between the end of the plastic and the bottom end of the tube. Cut the plastic that extends beyond the end of the small tube off. Cut another piece of foil 6” wide and tape it onto the outside of the plastic, not overlapping the overlapping ends of the plastic. It should extend from the bottom edge of the plastic (but not over the edge), up to the gap between the large cylinder and small cylinder. Again, it should be flat. Tape down all 4 sides.

Top view of cylinder



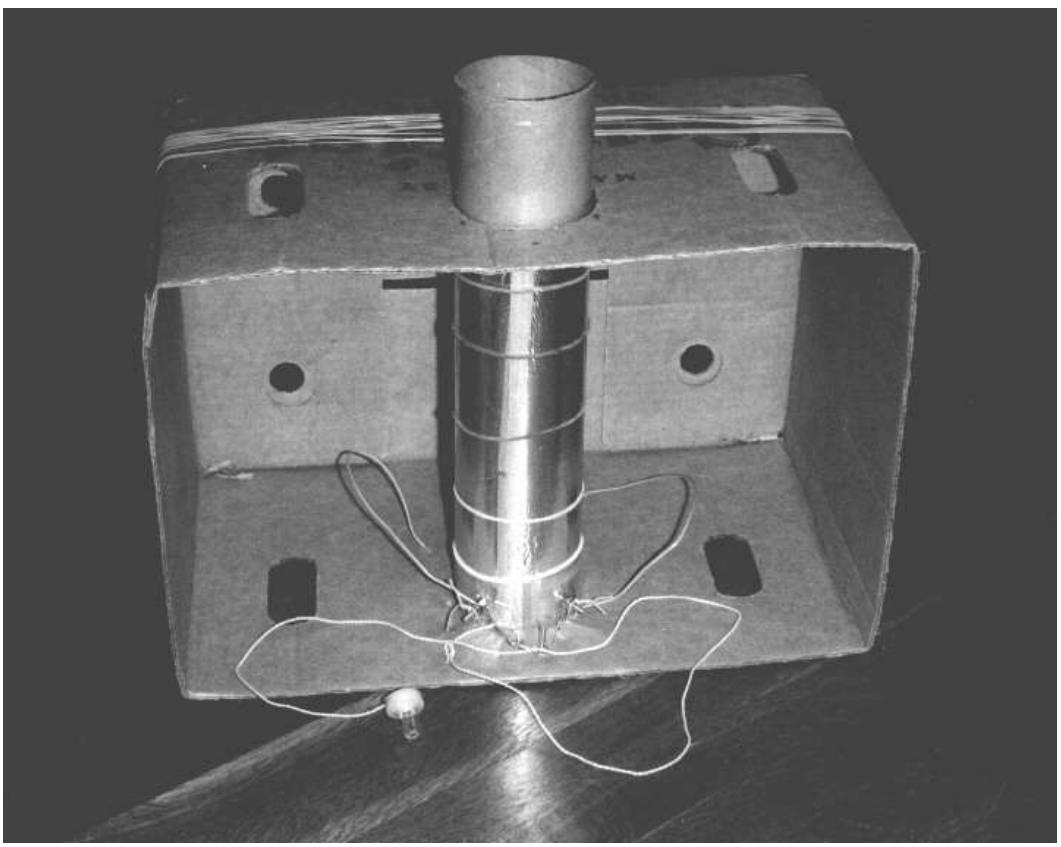
You should be able to rotate the plastic (with the foil on top of it) around. As you rotate it around, there should be a position where one of the 2.75″ pieces of inner foil is visible through the plastic and there is no overlap between one piece of inner foil and the outer foil. This is the minimum capacitance setting. If the 6″ foil is too long so that there is always some overlap, you may have to remove it and use a slightly smaller piece of foil. I placed several elastic bands over the tube to keep the layers of foil and plastic snug against each other,



maximiaing the maximum capacitance. This capacitor has a maximum capacitance of about 500pF.

Connections are made to the two pieces of foil with bolts through the bottom of the tube. I fasten the capacitor assembly onto the inside of the box, with the top “Tuning dial” protruding out of the top, as shown in the photograph.

The rest of the assembly is straight-forward. The diode and resistor are connected by wrapping their leads around a bolt, and securing it with a nut. The leads from the earphone are delicate, but can be handled a similar way.



Use

It’s simple: Plug the earphone into your ear, and slowly rotate the tube sticking out of the box. (The plastic sheet with foil taped to it should smoothly rotate around the tube, changing its capacitance.) Listen carefully, because it is not loud.

In my location, Ottawa, Canada, I could receive 4 strong local stations by twisting the tube around and listening to the earphone until they come in clearly. Most urban areas have some stations of sufficient strength to be received without an antenna. You will have better reception:
-Outside a building. Especially concrete and steel buildings.
-Up high, as opposed to in the basement.
-Rotate the box for best signal; the coil is quite directional.
-Day is better than night, because radio stations are often required to reduce their power at night. (This is because radio signals travel farther at night because of "skip", and can cause interference unless power is reduced)
-You can connect this radio to an antenna and/or ground. Try one or the other. For a really excellent radio, make a second crystal set (without the crystal and earphone), and place it next to your first set. By adjusting it, you will be able to pick up more stations. The antenna and/or ground can be connected to this second set.
-Try changing the number of turns in the coil. If you can not receive the station at the "low" end of the band (600kHz), you may need more turns. If you can not receive the station at the high end of the band (1400kHz), you may need to make the capacitor smaller.
-Try spreading out the coil
-Try larger coils with fewer turns
-Try different locations