Crystal Foxhole Radio

By:
Dilawer Singh

Lab Section: H3

Date Due: April 25, 2011

Radio waves were first predicted by James Clerk Maxwell in 1865 because he recognized the wavelike properties of light and electric and magnetic fields, and Heinrich Hertz furthered Maxwell's electromagnetic waves by being the first to create radio waves in his lab.[1] Guglielmo Marconi was the first person to actually invent a radio by receiving the world's first radio patent.[2] The first radios were called crystal radios and foxhole radios. These radios did not use any power except for the power that was transmitted within the radio waves which was picked up by an antenna. These were the simplest types of radios, and they were named after the crystal detector that was made out of some crystalline material such as galena.[3] The name "foxhole" comes from the fact that it does not use any power. Therefore, a crystal foxhole radio is one that uses a crystal detector and only the power from the radio waves to operate. Although there is not much physics involved in these types of radios, it should be discussed because it is a vital part of how they function, and the construction of these radios was not difficult, involving only a general understanding of how radios work.

First, crystal foxhole radios mainly use the fundamentals of physics to operate, so the understanding of its functions is simple. The power from the radio waves is used to transform radio waves into sound, and these radio waves are based on the principle of modulation. Modulation is the method for sending sound information on a radio-frequency wave by altering one or more traits of the sound wave in accordance with the original sound signal. A crystal foxhole radio only operates on AM-Amplitude Modulation-radio waves, and AM waves work by sending sound information on a carrier wave by changing the amplitude of the carrier wave in accordance with the sound signal being transmitted.[4] Once the radio picks these carrier waves up through its antenna, the antenna changes them into electric currents. These electric currents then travel through a tuned circuit which is a coil of wire called an inductor and within the coil of

wire is a ferrite rod, so particular radio stations can be tuned in by adjusting the rod in and out of the coil of wire.

After this, the currents travel through a variable capacitor which also allows one to tune to different radio stations because the variable capacitor offers a range of capacitances that affect the radio signals or electric currents. Next, the electric currents travel through a diode or a crystal detector and both of these components work the same. They are responsible for removing the audio signal from the carrier wave, and they achieve this by forcing the electric currents to flow in only one direction which blocks half of the oscillations. This causes the electric current to be changed into DC currents that vary in strength based on the radio waves. Lastly, these newly transformed currents travel to a pair of piezoelectric earphones which have a metal plate that vibrates in accordance with the sound waves, and then the music can be heard.[3]

Also, there is a portion of physics involved in the operation of the radio because this radio requires a part of the circuit to be connected to a good ground. A ground is basically something that is connected to a charged object to remove some of that charge. Therefore, this radio requires a ground, preferable the Earth, because energy from the radio waves begins to store up in the circuit which causes the electrons in the wire to fluctuate in accordance with the waves. After some time, there must be a place for this charge to go to prevent a back up of charge at the end of the circuit. Thus, the radio is connected to a ground, so these charges can flow easily in and out of the circuit resulting in a continuous flow of charge from the antenna to the ground.[5] Without the ground to complete the circuit, the radio will not work.

The second part of this paper will discuss the construction of a crystal foxhole radio set. First of all, a crystal foxhole radio is basically a foxhole radio that incorporates the crystal detector rather than a razor blade to connect the circuit. The basic parts that this project requires

are the following: some magnetic wire, a PVC pipe, a variable capacitor (30-300 pF), a crystal detector with galena, a piezoelectric earphone, an antenna, and a slab of wood for a base. A variable capacitor is used because variable air-dielectric capacitors tend to have low losses at radio frequencies. This can be attributed to the fact that air is almost a perfect dielectric medium, and since air is the typical dielectric used in these variable capacitors, there are low losses of radio signals.[6] Initially, the coil of wire was constructed by cutting a piece of PVC pipe with a diameter of 1 inch into a length of 5 inches. Two holes were drilled next to each other at both ends of the PVC pipe. The magnetic wire was inserted into the hole that was closest to the end and looped around through the hole next to it. The wire was wrapped around the PVC pipe the whole length of the pipe and inserted into the second hole and looped around through the hole closest to the end at the other end of the pipe. Then, the two ends of the wire from the coil were sanded and straightened.[7] The pipe was then nailed to the board.

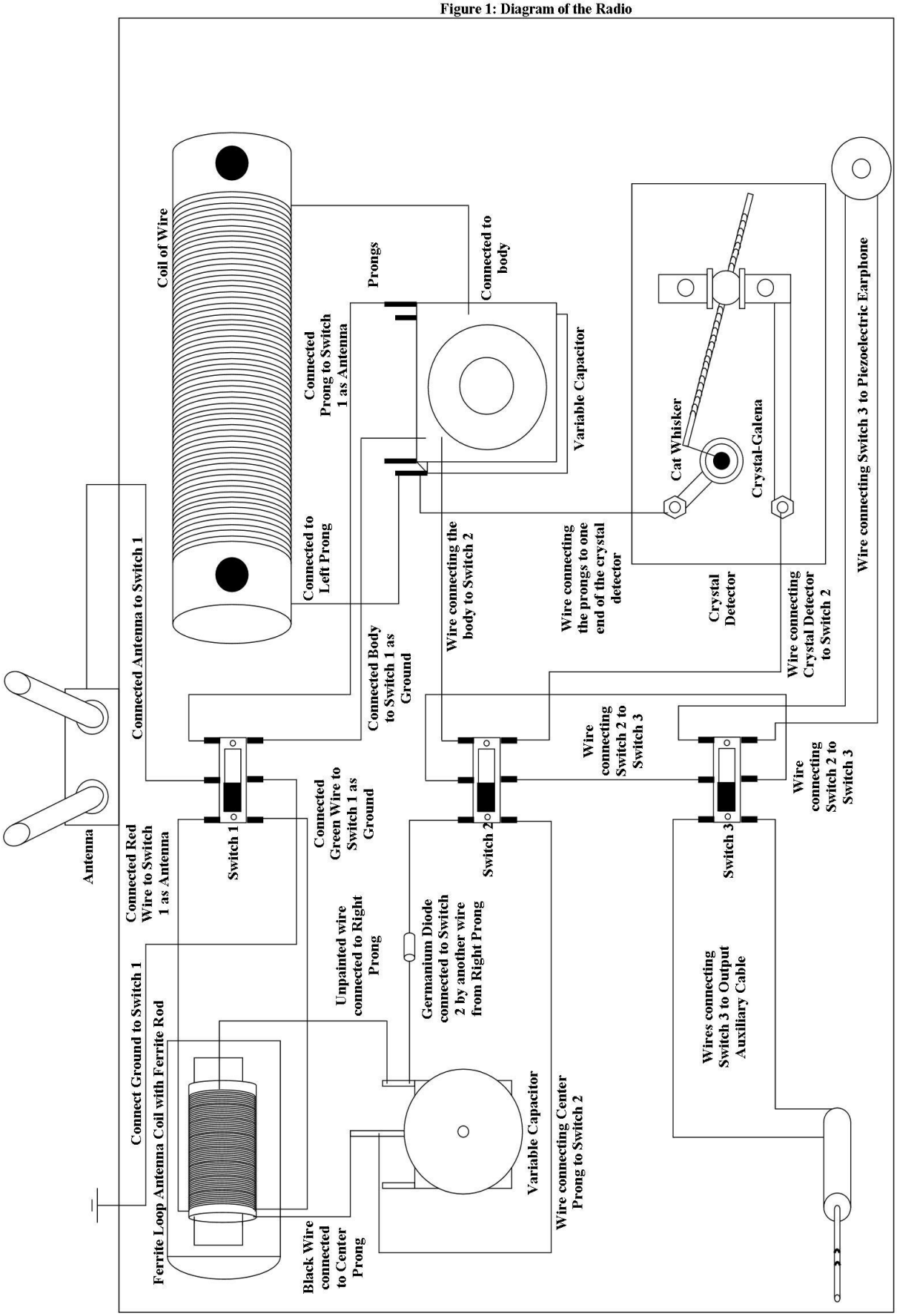
After the coil of wire was constructed, the variable capacitor was placed onto the wood base and the two ends of the coil were soldered to the variable capacitor leads. There are four prongs that come out of the capacitor. When the prongs were pointing upwards and the turning knob outward, one of the ends was soldered to the left prong, and the other end was soldered to the body of the variable capacitor. Another wire was soldered to the left prong, and this wire connected the capacitor to the crystal detector. The ground was connected to the body of the variable capacitor, and the antenna was connected to the left prong. Lastly, one end of the piezoelectric earphone was connected to the other end of the crystal detector. The other end of the piezoelectric earphone was connected to the body of the variable capacitor.[7] The crystal foxhole radio is complete after the ground wire is connected to a good ground.

In addition to the crystal detector set that was built, another radio set was built, but instead of using a crystal detector, a Germanium diode was used to test the difference between the crystal detector and the diode. In this project, the parts that were needed were the following: a ferrite loop antenna coil, a variable capacitor (30-160 pF), a Germanium diode, a piezoelectric earphone, an antenna, and a base. First, when the variable capacitor has its prongs pointing upwards and the turning knob outwards, the black wire from the ferrite loop antenna coil is soldered onto the center prong, and the unpainted wire is soldered onto the right prong. Also, one end of the Germanium diode is soldered onto the right prong. After this, one end of the piezoelectric earphone is soldered to the other end of the Germanium diode, and the other end of the piezoelectric earphone is soldered onto the center prong of the variable capacitor. Then, the green painted wire of the ferrite loop antenna coil is connected to the ground, and the red painted wire of the ferrite loop antenna coil is connected to the antenna.[8] The radio is complete. To be able to put both radios on the same base, three switches were incorporated into the design to switch between the radios.

In conclusion, this project explored how basic radios work by reducing a modern radio down to its essential elements. The fact that radio waves are enough energy to power the simplest of all radios was proven, and the physics that was involved in this project was easily understandable. The construction of this project was not difficult at all, but it did involve precision to be able to tune the capacitor or the crystal detector to a certain radio station. It is surprising that the skill in making crystal foxhole radios can still exist today just by using some basic electrical components and a little knowledge of how radios operate. Thus, over a century after the first radio was developed and after many modifications to its design and functionality,

the modern radio was achieved, but it all started with Maxwell, Hertz, and most importantly Marconi with the radio waves and crystal and foxhole radios.

Figure 1: Diagram of the Radio



Bibliography in Chicago Style

1. "Radio Waves," *Wikipedia: The Free Encyclopedia*, http://en.wikipedia.org/wiki/Radio_waves (accessed April 21, 2011).
2. Nahin, Paul J. *The Science of Radio*. New York: Springer-Verlag, 2001.
3. "Crystal Radio," *Wikipedia: The Free Encyclopedia*, http://en.wikipedia.org/wiki/Crystal_radio_receiver (accessed April 22, 2011).
4. Encyclopedia Britannica, "Modulation," *Encyclopædia Britannica. Encyclopædia Britannica Online*, http://www.britannica.com/EBchecked/topic/387402/modulation (accessed April 22, 2011).
5. "Chapter 4: Radio," *Science Toys*, http://sci-toys.com/scitoys/scitoys/radio/loop_xtal_radio/loop_xtal_radio.html (accessed April 23, 2011).
6. Technical Advertising Associates, *Radio Component Handbook:1st Edition*. Philadelphia: Dunlap Printing Company, 1948.
7. Bizarre Stuff, "Foxhole and POW Built Radios: History and Construction," *Bizarre Labs*, http://bizarrelabs.com/foxhole.htm (accessed April 23, 2011).
8. "Chapter 4: Radio," *Science Toys*, http://sci-toys.com/scitoys/scitoys/radio/ten_minute_radio.html (accessed April 23, 2011).