Adam Goss
Phy 475
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Final Project Fun with Ferrofluid

For my final project I chose to build and design a ferrofluid fountain.   The purpose of this project was to create something that people without knowledge of physics can enjoy.   My personal goal was to build a circuit that is capable of manipulating a magnetic field through the use of an iPod, thus controlling the fluid with music. While the ferrofluid is for show it serves to visually showcase the active audio filters.

Ferrofluid is a magnetic fluid that becomes magnetized in the presence of a magnetic field.   A picture of this can be seen in figure 1. The spikes are 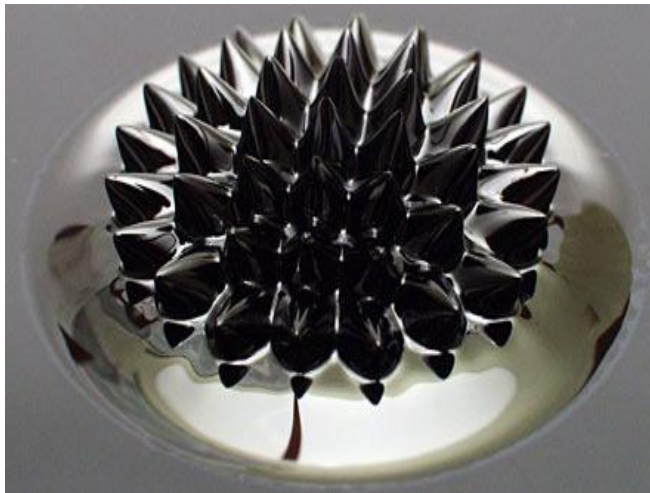created when the small metal partials suspended in the fluid reorient themselves along the magnetic field lines. Simultaneously the Van der Waals force [1] works to hold the solution intact.

Figure 1 shows ferrofluid in the presence of a magnetic field.

Electromagnets were used to increase and decrease the magnetic fields strength and work through the use of moving current.   Magnetic fields are created by moving charges in this case current. The direction of the current can be found by using the right hand rule shown in Figure 2.
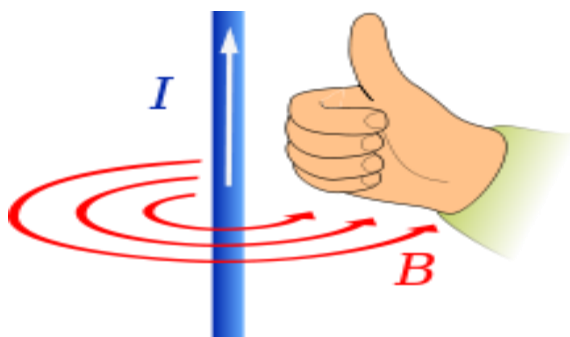
To obtain a magnetic field traveling in the same direction wire is wrapped in coils as shown in Figure 3.

Figure 2 shows the direction of the magnetic field relative to the current.
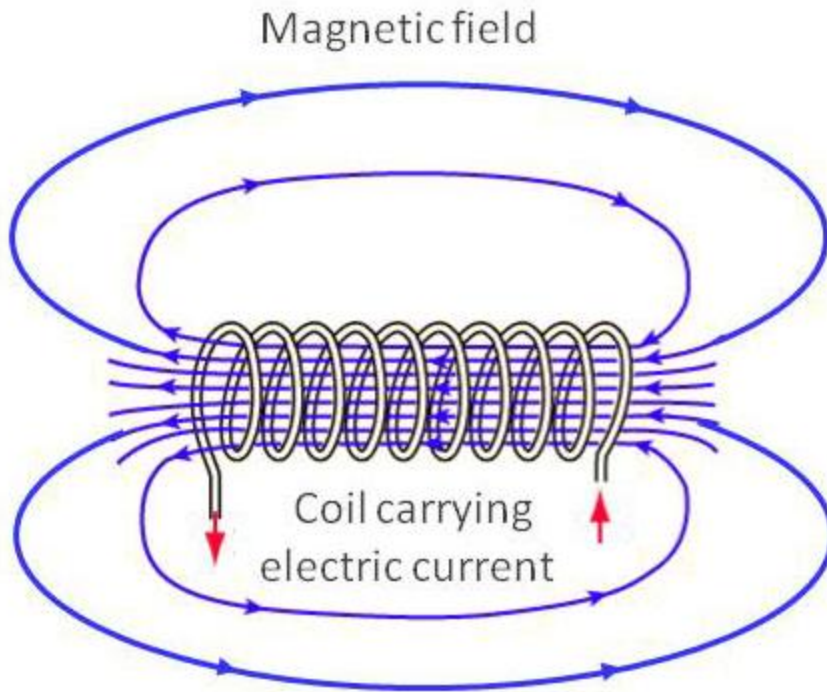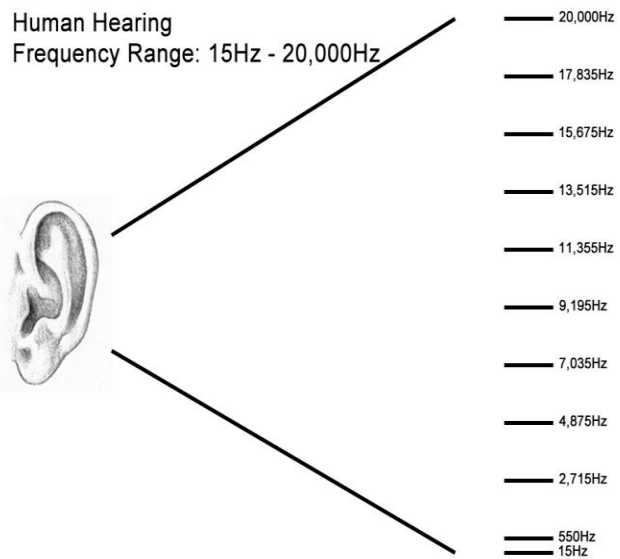
Magnetic field

Coil carrying electric current

Figure 3 shows how coils carrying current can be used to create a magnetic field.

The project consisted of the following:

- Five Signal Amplifiers
- 1/8 inch audio jack input
- Four Electro Magnetics
- DC power source
- One Speaker
- Ferrofluid
- Active Audio Filters
  - 20Hz - 4kHz
  - 4kHz - 10kHz
  - 10kHz - 15kHz
  - 15kHz – 20kHz

The ranges of the audio filters were chosen based on the range of human hearing shown in Figure 4.

Human Hearing
Frequency Range: 15Hz - 20,000Hz

- 20,000Hz
- 17,835Hz
- 15,675Hz
- 13,515Hz
- 11,355Hz
- 9,195Hz
- 7,035Hz
- 4,875Hz
- 2,715Hz
- 550Hz
- 15Hz

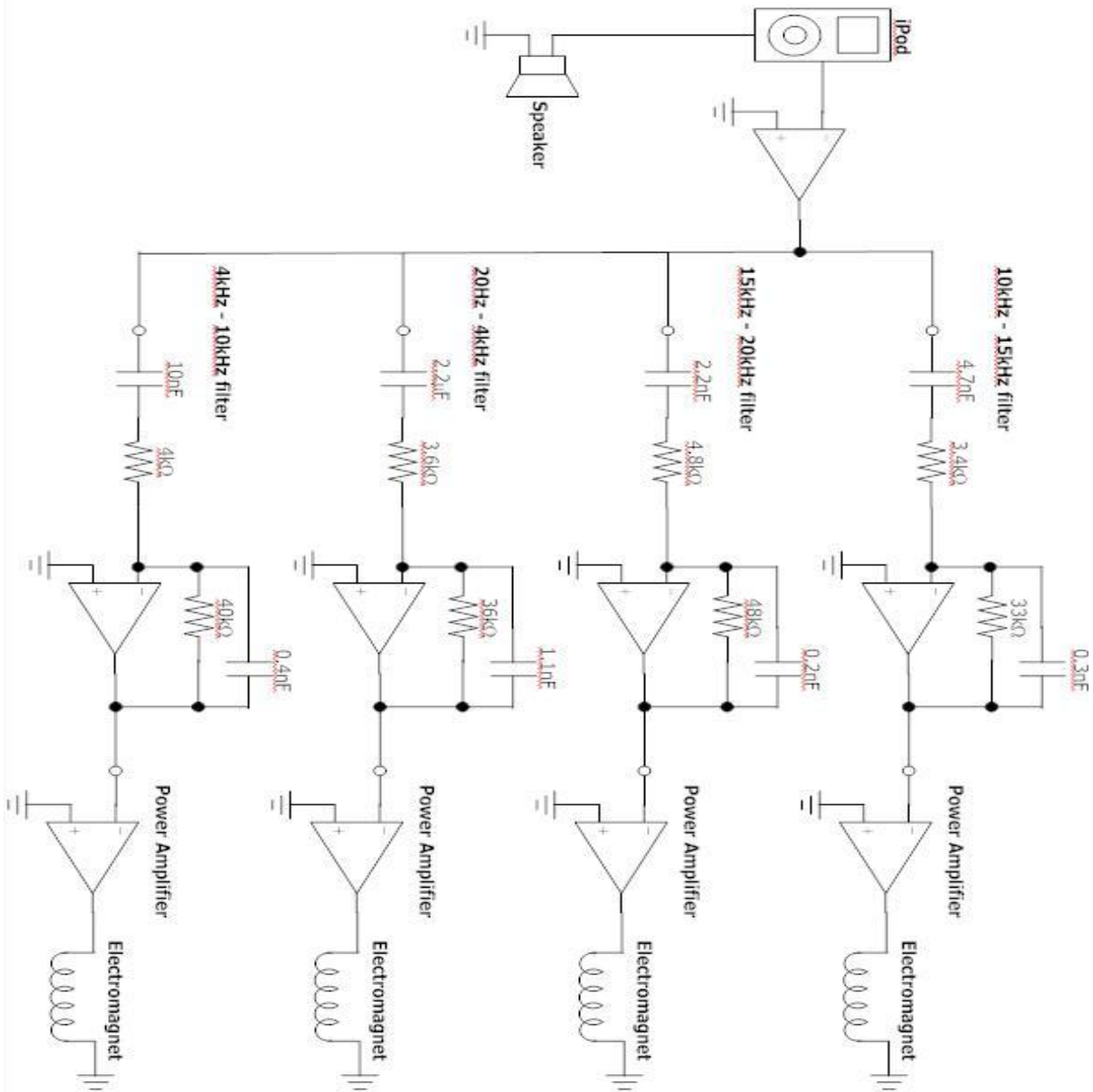Figure 4 shows the range of human hearing.

Figure 5 shows the schematic of the project created.

The resistances and capacitances used in conjunction with op amps to create the filters can been seen in figure 5.

While this circuit worked there were several areas in which it could be improved.   The biggest problem I encountered was not getting enough current though the electromagnets.   This problem could be fixed with the use of amplifiers that are capable of putting out more current.   Another area that could be improved would be the range of the audio filters. After making the circuit shown in Figure 5 I quickly learned most music lies within the 5kHz – 10kHz range. If I were to make this project again I would only filter the music between 20Hz and 14kHz. Another improvement I would have liked to implement would have been to make it possible to listen to the music after going through the different filters. When working on this project I found the filters created a lot of noise and would need to be redesigned if we wanted to listen to the music coming out of the various filters.

This was the first time I have ever designed and created my own circuit and I was pleased to see it work. While my circuit was simple in design and could be improved upon I feel I achieved what I set out to do while learning many things.