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Process Description: Headphones

Headphones are a commodity that prove to be an incredible feat of both mechanical and electrical engineering. As common as headphones are, their complexity isn't done any justice by the apparently simple design. Both the audio jack and the main wire comprise of the major electrical engineering components of the headphone. These parts are essential as the power source to the headphones, as well as controlling the specific currents transferred from the device to the speakers. The speakers are where mechanical engineering truly shines. Cone shaped films are vibrated at very high frequencies, determined by the amount of current flowing through the wires of the headphones. These currents are transferred into an electromagnet that transmits electromagnetic waves, which ultimately vibrate the cones in the speakers. All of these components of headphones are significant in that they act as gateways to new innovations in engineering and design. It is a beautiful example of the interdependence between electrical and mechanical engineering, which is funneled by electromagnetic energy.

Electrical Engineering:

i. At the base of the headphones the audio jack is connected to the device, which acts as the power source. In most cases, this audio jack is a metal rod that has at least two separate rings, each of which is dedicated towards one of the speakers. These rings on the plug are important in order to make distinctions between currents sent to the left and right headphones [1]. The metal on the audio jack is divided by the rings so that some parts of the metal send currents to the right speaker while other parts of the metal send currents to

the left side. When an in-line microphone is present, this audio jack will have three rings to accommodate the information sent to the microphones.

ii. According to WIRED, “At the most basic level, an earphone is a loop of wire with current running through it” [1]. Each speaker has its own complete circuit so that there can be separate electric currents for both headphones. Each phone needs at least two wires connecting it to the power source to complete the circuit. The current is sent from the device to the speaker, and then sent back from the speaker to the device after being processed by the speaker.

iii. The device decides the power of the current through its programming, allowing for a variety of sounds at different amplitudes. Chris Woodford does an excellent job of explaining this when saying “Banging a drum skin really hard makes the skin vibrate a greater distance and produce a louder sound. In the same way, sending a bigger pulse of electricity into a loudspeaker makes the cone move further and generates a louder noise. Quieter sounds are made by smaller pulses of electricity” [2]. The idea that there are individual currents for each speaker, and that the device can control the power of each current allows for millions of combinations of sounds. Such a simple object consequently has the ability to play sound from limitless amounts of songs, videos, or anything else. However, this process becomes very interesting regarding the mechanism the headphones use to process and convert these currents into waves.

Electromagnetic waves

i. The current is sent through a wire in the speaker that is wrapped around a metal cylinder. Essentially, an electromagnet is created through this mechanism, as the current flowing through the wires magnetize the metal around it [3]. The mechanism takes advantage of an electron’s magnetic properties. Sending an electric current through a wire that is

wrapped around metal will attract the electrons surrounding that metal in a specific direction [4]. As such, having all of these electrons acting in unison towards the same direction will create a magnetic field in that particular direction. An electromagnet is turned on when the coil of wire wrapped around the metal has a current running through it. The electricity therefore is a necessary ingredient to the magnetic field around the metal, creating a magnet that has the ability to be turned on and off at will. This is very significant, because turning the magnet on and off will ultimately be the key to the sound being produced from the diaphragm in the headphones.

ii. The strength of the current ultimately determines the strength of the overall magnet inside the speaker. Amazingly, this same technology is what is used to move wreckage in landfills. With enough metal and wire, these magnets can be made so powerful as to lift entire cars off the ground [3]. Rather than strength of the magnet however, the headphone is a great example of the magnetic field's precision. Changing the velocity of oscillation within the current affects the frequency of charges affecting the electromagnet [5]. If the current moves through the circuit very fast, then the current produced has a shorter wavelength and a higher frequency. Vice versa, slowing down the speed of the charges flowing through the wires will produce higher frequencies. This is what gives headphones the capability to play the raucous sounds from a rock concert, or the soothing melodies of a lullaby. According to Schultz Innovation, "The usual frequency range of headphones, at least as it is declared on the packaging of headphones, includes frequencies from 20 Hz to 20,000 Hz, which is what an average human can hear" [6]. However, a drawback of these waves is that they aren't carried through any mediums such as air or water. Accordingly, the sound coming from your headphones in reality

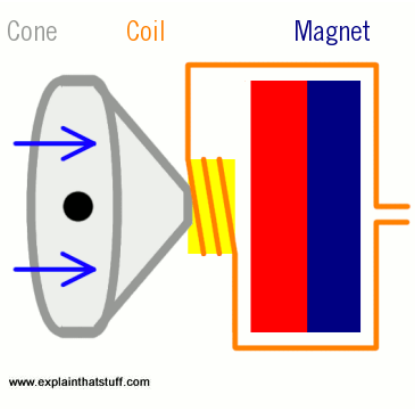
aren't electromagnetic waves, but compressional waves that result from the electromagnetic waves interacting with the voice coil and diaphragm.

Mechanics in the Diaphragm

i. The electromagnet beneath the diaphragm is attached to a voice coil made of iron, acting as the conduit between the diaphragm and the magnet [2]. The electromagnetic waves push and pull the coil at incredible speeds, resulting in vibrations in the concavity of the diaphragm.

ii. The diaphragm is a cone shaped piece of paper that acts as the main speaker to the headphone. The edges of the diaphragm are fit snugly at the edges of the speaker to avoid the whole diaphragm from being pulled back and forth [2]. These vibrations finally create compression waves in the surrounding air.

Figure 1



[2]

iii. This is the "sound" that we all hear when blasting music in our ears. All of the individual energy in this system work in unison to create the final product of vibrations that the cochlea in our ears is able to process into information. In this manner, the frequency and amplitude of all waves produced during this process are directly proportional to one another, making the job of the engineer a bit simple in that aspect. The frequency of electromagnetic waves is also directly proportional to the frequency of vibrations produced by the diaphragm, because a higher frequency of electromagnetic waves will result in vibrating the diaphragm at a faster rate.

This commodity, which is basically two complete circuits that are connected to two cones, has become one of the most widely owned products today. Dissecting its makeup gives a glimpse into the logic that goes into engineering. The ingenuity found within this product is held more deeply in the relationship between its various mechanisms, rather than any sort of great design. A pair of headphones may not necessarily have to look pretty, but its precision in sound and connection to the device it builds makes it a simple product that everyone must have.

Reference List

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