How Electric Guitars Create Sound

A traditional acoustic guitar creates its sound entirely through vibration. Strings are pulled taught over an opening to a hollowed out body and by striking the strings with fingers or a guitar pick, the strings vibrate. By pressing the strings down on the fret board with their fingers, guitar players shorten the length of the string thereby decreasing the wavelength at which it is vibrating. All of these vibrations resonate within the body of the guitar and are amplified to much louder volumes. An electric guitar is identical to an acoustic guitar in how the vibrations are created; however, an entirely different process is used to amplify them. Electric guitars take advantage of a phenomenon called electromagnetism and use devices called pick-ups to detect the vibrations of the strings. The vibrations are then sent from the pickups to an amplifier and a speaker.

Electromagnetism and Guitar Pick-ups

Electromagnetism is the phenomenon that whenever there is a change in a magnetic field, it induces electricity. The reverse is also true; changing an electric field generates magnetism. Guitar pick-ups, as seen in Figure 1, are made by taking magnets and wrapping hundreds or thousands of coils of thin wire around them. The guitar pick-ups are placed in the body of the guitar directly underneath the strings. This allows the magnetic field created from the magnets in the pick-ups to pass up through the strings.

Whenever the strings are played, the vibrations of the strings slightly change the magnetic field of the magnets. Because of electromagnetism, this change creates an electric field that flows through the tiny wires wrapped around the magnets, as shown in Figure 2. These small currents are then slightly altered by volume and tone circuits built into the guitar and controlled by knobs. Finally, the currents flow out of the guitar through the guitar cable.

Figure 1 found at: www.ocduffpickups.com

Figure 2 found at: clearsscience.tumblr.com
The Amplifier: The Pre Amp and the Power Amp

The electronics behind amplifiers can get complicated, but they can be simplified into two parts. The first part is the preamp and the second is the power amplifier. The preamp, shown in Figure 3, takes the current that is coming through the guitar cable and prepares it for power amplification. This preparation often includes a small boost in amplitude as the signals coming from the pickups are so small. Preamps can also act as a filter for the signal. If the signal coming from the pick-ups is scratchy or noisy then a preamp can filter this out, creating a much more pleasant tone. Lastly, most preamps come with some sort of an equalizer. An equalizer is a complex circuit that allows the user to boost or cut certain frequencies of the incoming signal. By increasing higher frequencies, the signal can be made to sound brighter. By boosting the bass frequencies, the user can create a fuller and deeper sound, and so on.

The second part of the amplifier, the power amp, is much simpler. As its name suggests, its purpose is to solely add power to the signal. There are two different types of power amplifiers used today. The first type, shown in Figure 4, adds power to the signal by using an electrical component called a transistor. Transistors allow frequencies in small signals to be replicated in much larger signals. Power from the wall outlet is used to power the final signal that is finally sent to the speaker.

The second type of power amp, the original power amplifier design, uses components called tubes instead of transistors. Tube amps, like the one in Figure 5, accomplish the same task as transistor amplifiers, but many guitarists claim they produced a better sound and will still use them today. The significant downside to tube amplifiers is that they do not last very long and the tubes may need replaced after only 6 months to a year.

Figure 3 found at: en.audiofanzine.com
Figure 4 found at: www.diyaudio.com
Figure 5 found at: www.valvetubeguitaramps.com
Electromagnetism Inside of a Speaker

Speakers also rely on electromagnetism in order to work. Speakers have two magnets inside them, one normal magnet that is permanently fixed, and then an electromagnet. The electromagnet is a coil of thin wire that creates a magnetic field whenever a current is run through it. This electromagnet is not fixed so it can freely move in relation to the permanent magnet. Figures 6 and 7 show the design on a speaker.

Because sound travels in waves, the signal going through the electromagnet will continually change, causing the magnetic field it produces to constantly change as well. This causes the electromagnet to be continually attracted to and then repelled by the permanent magnet. The speaker cone, which is attached to the electromagnet, is thereby made to vibrate at the frequency of the signal coming from the amplifier. This vibration pushes sound waves through the air and into the ears. Figure 8 shows the amplifier and a speaker box combination.

Conclusion

Electric guitars are complicated instruments that use properties of electromagnetism in order to produce sound. Guitar players control the wavelength of a string’s vibration by pressing the string down on various frets. Pick-ups on the guitar body detect vibrations in the strings through changes in their magnetic fields. Then through electromagnetism, the pick-ups convert the vibrations into a signal that leaves the guitar through a guitar cable. From there, the signal runs through a pre amp which prepares it to then be amplified in volume inside the power amp. After leaving the power amp, the signal is now strong enough to push the cone of a speaker, again making use of the properties of electromagnetism, and thus producing the sound of the guitar.