Mini Van de Graaff Generator

By Taylor Kitchens

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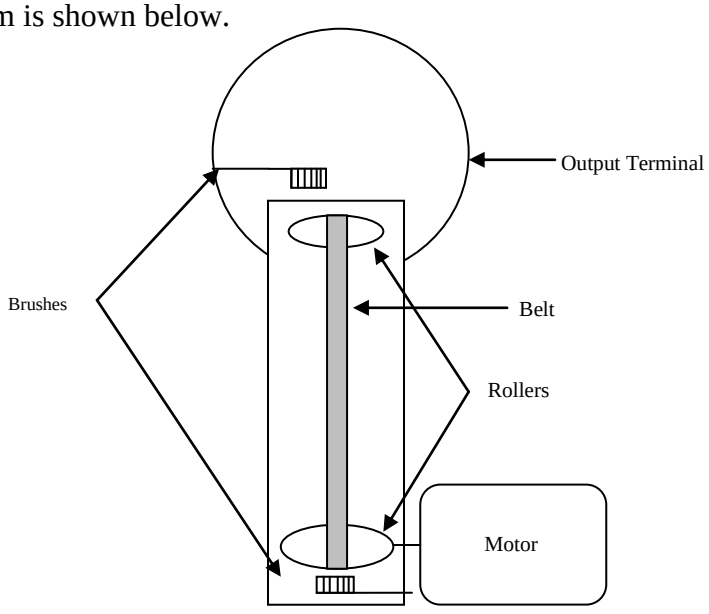
Section H1

Introduction

A Van de Graaff generator is a type of electrostatic generator that uses a moving belt to generate and transfer static electricity. The first type of electrostatic generator was built in the late 17th century; however the Van de Graaff was invented in 1929 by Robert J. Van de Graaff. There are two types of this generator: one that uses high-voltage power for charging, and one that uses belts and rollers for charging (Zavisa). For the purpose of this Honors Project, the focus will be on the belts and rollers type of Van de Graaff generator, because of the accessibility and cost materials.

Physics of a Van de Graaff Generator

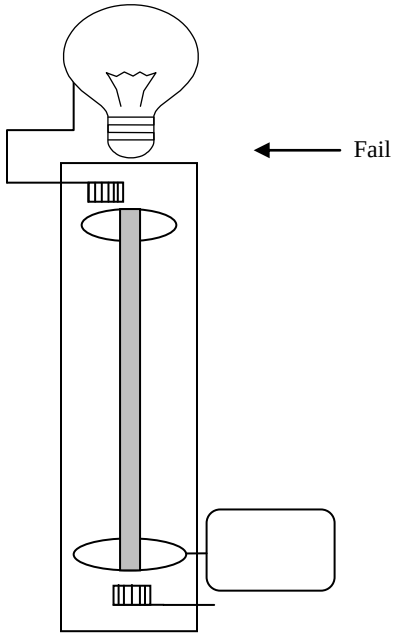
The belts and rollers type of Van de Graaff generator has a few major components: a motor, two rollers, a belt, two brushes, and an output terminal (usually a sphere). Once the motor is turned on, the lower roller begins to turn. A charge is generated at the lower roller while an opposite charge is generated on the belt. This is because the lower brush takes some of the charge into a ground and leaves the belt charged with the opposite. Whether it is a positive or negative charge will depend on the where the material is located in the triboelectric series. As the charge is carried up the belt, it is transferred at the upper roller into the output terminal by the upper brush. A simple diagram is shown below.



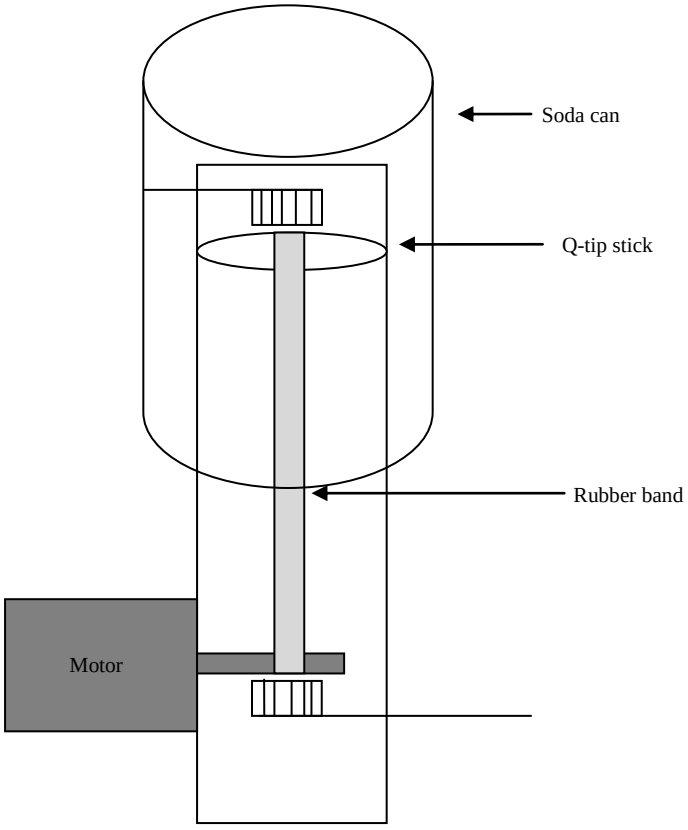
Construction

Attempt #1: First, I attempted to build a generator using one set of online instructions. This called for the ink cartridge of a pen for rollers, PVC pipe for the housing, a rubber band for the belt and a dead light bulb covered in aluminum foil for the terminal. I used a 3.0 volt motor for this design. This model never generated a spark once it was all put together (Instructables). I played around with it some trying different rollers, but decided to search for other models once this one failed.

Attempt #2: After researching other homemade Van de Graaff generators, I decided it would be a good idea to redesign the part that houses the rollers, belt, etc. to try and get better connections between them. I bought a t-connector for the PVC pipe that would hold the motor still. This fixed one of my troubles in the first attempt since I continuously had to hold the motor to make it run. I connected a piece of the pen ink cartridge to the shaft of the motor making it the bottom roller, and the paper rod of a Dumdum sucker served as the top roller. This attempt was still using the dead light bulb covered in aluminum foil and the 3.0 motor. This attempt also failed and did not result in a spark from the aluminum; however, it did result in a dead motor that I managed to superglue , and a second trip back to Radio Shack.



Attempt #3: (The third time's a charm!) The second trip to Radio Shack resulted in a larger DC motor (9V) and therefore a larger PVC pipe-connector. After repeating the previous steps, I upgraded to a Q-tip stick which was considerably sturdier than the Dumdum stick for the top roller. In this attempt I decided to use just the motor shaft itself as the bottom roller, so I removed the ink cartridge. I also found online that a modified soda can be a good option for the output terminal, and so I replaced my dead light bulb with an empty soda can. After reassembling the entire generator again, I crossed my fingers and gave it a go. A small but mighty spark was generated from the can! Finally success! Below is a diagram of the final generator.



According to the triboelectric series, paper is more positive than the motor shaft. Therefore, in this Van de Graaff generator, the rubber band is first negatively charged because it steals electrons from the paper rod at the top as it spins around. This leaves the paper rod highly concentrated with a positive charge. It then attracts the electrons from the top brush. The electrons spray out of the ends of the wire and charge the air. The air is attracted to the paper rod, but cannot reach it because the rubber band is in the way, so they hit the rubber band and transfer to it instead. The rubber band travels back down toward the bottom and the electrons are transferred through the bottom brush to whatever is grounding that wire. After this occurs, the rubber band and the bottom brush have a positive, thereby attracting the electrons from the air. They both then become neutral as it travels back up to the paper rod. Since the top brush is connected to the inside of the can, it uses the electrons from the can to spray into the air around the paper rod. This leaves the can with a lot of positive ions that travel to the outside of the can. Because it is not a perfect sphere, the charge will be more concentrated in the areas with sharper edges. (Field)

Conclusion

After much trial, error, and learning, a successful miniature Van de Graaff generator was constructed. At first I believed that the output terminal had to be completely spherical with no edges, so I spent a lot of time on smoothing out the aluminum foil on the light bulb. Even though the light bulb design did not work, I did benefit from its failures. I went back to the drawing board and constructed a completely new generator with a slightly different design. The lesson learned: If at first you don't succeed, try, try again. I now know why and how my generator works.

Works Cited

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