Van De Graaf Construction

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Preface

The physics behind the Van De Graaf at first seemed quite complicated to me. Yet after researching the triboelectric series, half a semester of learning about electricity, and researching forums on Van De Graaf construction I understand what I built and have been able to improve it on what I've learned and through trying different materials.

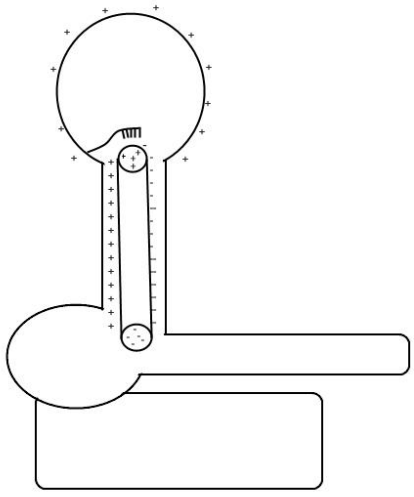
Introduction

Van De Graaf generators were originally created for use on particle accelerators, such as the accelerator at Fermilab. The first Van De Graaf was made using a silk tie and glass roller. This historical setting would have been attempted, yet destroying a silk tie did not seem worth it, as silk ties run well over $40. If a cheap silk tie is found, the arrangement will be attempted at a later date.

This article will discuss the construction of the VDG on display, the physics behind it, and a conclusion on the project along with a breakdown of costs if one is interested in building a VDG.

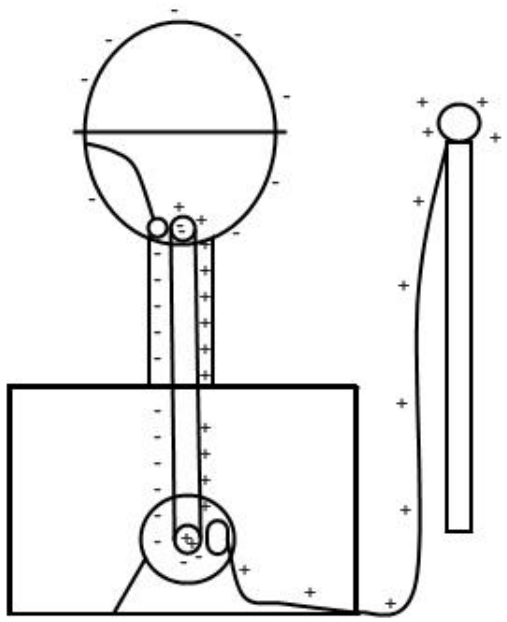
Construction of the VDG

This Van De Graaf was originally constructed using an old belt sander, a piece of PVC tubing, two metal bowls, a glass upper roller, and a bicycle inner tube. When assembled like the diagram below it created sparks, yet the motor burned out and the machine had to be reconstructed.



VDG Figure A

Using the same materials, but now mounted on a wooden box, and the motor from a box fan, the machine was reborn. Different belts and upper rollers were tried and it was found that the inner tube did not conduct as much electricity as the PVC roller and latex balloons, so the machine now bears those materials instead of the ones the original one utilized.



VDG Figure B

The charge produced could be increased by using a more positive lower roller, such as one made of glass, as this would increase the charge separation. It could also be increased by attaching a faster motor, which would decrease the contact time between the belt and rollers and also reduce the amount of time the charge has to dissipate into the air along the path of the belt. One other way the charge produced could be increased would be by having a wider belt, as it would increase the surface area that the roller and belt touch, which would yield more available charge.

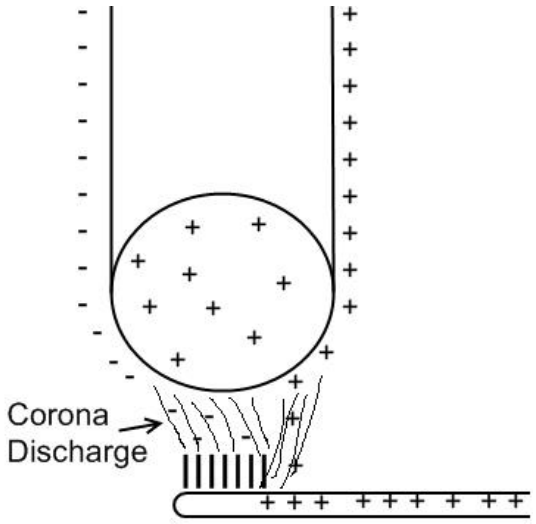
The Physics of the VDG

The upper roller is made of PVC and the lower roller is made of aluminum, the two are quite far apart in the series and this is important as the rollers attract different charges. The PVC has the tendency to capture electrons, which makes the upper brush become positive and the belt also to become positive, as positive ions from the comb attracted to the electrons on

the roller leave the comb and land on the belt in a process called corona discharge. As this discharge continues, the upper sphere becomes negative as it loses its positive charges.

The Aluminum roller on the bottom attracts these positive charges and makes the lower brush negative by induction. The negative charges leave the lower comb to the belt via corona discharge, which then jump onto the sphere because of the negatively charged PVC roller. By doing this I will create a bigger spark with the grounding rod than I would had I connected the lower brush to the ground in the wall outlet. This is what is known as doubling the current.

Below is a diagram of what happens at the lower roller:



Van De Graaf generators produce a constant electric current instead of a constant voltage, like a battery does. Voltage is known as the potential difference and the potential difference increases with distance. The voltage across a Van De Graaf changes depending on the humidity, and the distance between the grounding wand and the sphere. For instance yesterday when I was playing with the machine, the greatest spark I could achieve was about 1 cm, yet this morning when I was playing with it I was able to achieve sparks up to 10cm as the humidity in the air had decreased. Another example comes from playing with a florescent tube: the voltage through the tube increases the further away I pull the tube from the sphere, and this can easily be displayed by the intensity of the light emitted from the bulb.

Conclusion of the Project

The project went smoothly, other than the three motors that I burned, and the glass roller that I broke. Accidents happen when working on a project, and burning up equipment also happens, this is something I've learned will occur throughout my career in physics.

The machine did almost everything I wanted it to do; the only thing it didn't achieve was getting my hair to stand on end. I was able to light a bulb, and able to get a visible spark. The days that I tested the hair standing on end were also very humid days and I live in a very old home that does tend to retain humidity, so these two factors may have reduced the machine's ability to raise my hair.

While the machine is a fun toy for me to have, it also came at a decent expense. The following is a breakdown of the expenses if you're looking to make one:

The sphere: Two mixing bowls $25

The motor: From a box fan: $15

The PVC piping: $15 for all of the various sizes

The box: $20 for the sheet of plywood

The belt: $5 whether you use balloons or an inner tube

The lower pulley: $5

Mine was considerably more expensive to build as I burned up three motors in the process and broke two glass rollers that I paid $10 a piece for, so my VDG cost roughly $100, but it was worth it as I learned a lot about the physics behind it and now have a VDG of my own to play with when I'm bored. If you were to build your own, I would suggest purchasing a kit from a website as to reduce trial and error, unless you're building one to see how powerful you can build one.

Bibliography and References

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http://www.eskimo.com/~billb/emotor/vdg.html, viewed on September 29th

http://www.science-house.org/learn/vdgraaf.html, viewed on November 13th