How Not To Make a Van de Graaff Generator

By John Monkus

This project was supposed to be a way to build a Van de Graaff without spending a lot of money that would produce very large sparks, however it managed to fail on both parts. Lack of preparation showed up both on receipts from various supply stores and in the overall failure of the damn thing to do anything at all. So to try and salvage this project it has taken on a new role of explaining how a Van de Graaff should work and how the non-working Van de Graaff did not work.

How a Van de Graaff generator should work

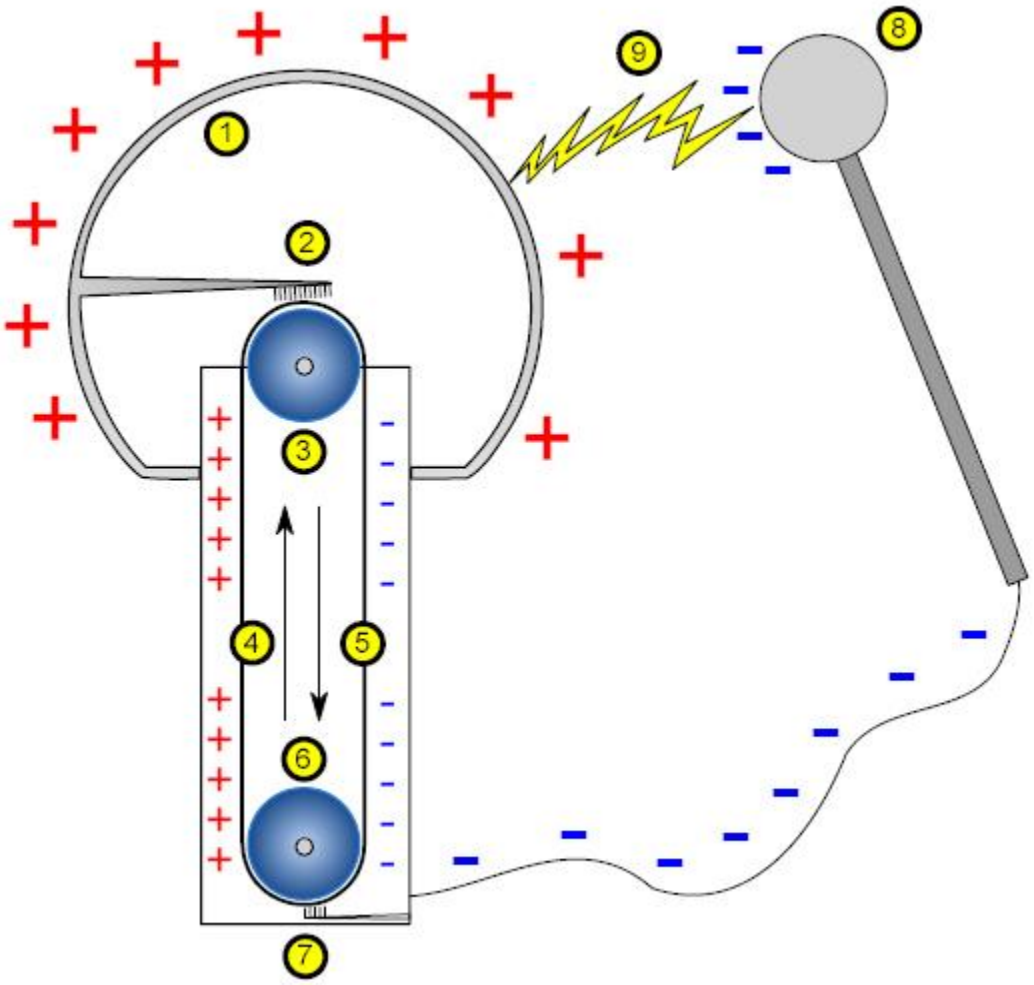

Fig 1. Working Van de Graaff. Ignore the various numbers; there were captions for them, but they aren't going to show up here.

A Van de Graaff generator is a machine that uses a constant current to produce varying voltages. This changing voltage is seen through sparks given off by the sphere when enough charge has accumulated. There are four very important materials needed to gain a charge on a Van de Graaff: rollers, a belt, two charge collecting combs, and the sphere.

To build a good Van de Graaff generator the rollers must be made of materials on opposite ends of the triboelectric series. The triboelectric series are a list of materials categorized by the charge they gain when in contact with a material on the opposite end of the series. In the case of the non-working Van de Graaff built for this project the rollers are a glass roller (positive) and a Teflon tape coated roller (negative).

The belt material is important for a working Van de Graaff because it carries the charge across the belt. The belt material needs to be made of some type of material on the triboelectric series. Most belts are made from some type of plastic or rubber and tend to be negative on the triboelectric series. Some belts are made from panty hose (Nylon) or Silk and tend to be positive on the triboelectic series. When the belt is spun around a roller of the opposite end on the triboelectric series it will produce opposite charges on both.

Once the charge begins to accumulate the combs move the negative charge off of the belt through the grounding comb and deposit the positive (say that 5 times fast) charge onto the conducting sphere.

The sphere will take this charge and distribute it all over so long as the sphere does not have many bumps or jagged edges. In the non-working Van de Graaff built in this project the sphere might be a bit to jagged at the hole cut out with a Drimel tool. This could possibly be fixed by sanding the edge and using a copper ring at the bottom to fold back the charge that tries to go to the bottom.

Various Attempts to make a working Van de Graff

In the process of failing to make a Van de Graaff Generator many permutations of materials that will not create a Van de Graaff have been employed.

Run #1

- Using rollers of the same material. (Derlon. Could not find on the triboelectric series)
- Using a vinyl shower curtain in conjunction with the two rollers of the same material. (note: more than likely the rollers and material would all be in the negative in the series)
- Using a 10” diameter gazing ball whose inner surface is rugged from being wield together.
- Using a comb made by soldering stick pins to a hammered copper pipe, and then placing at a distance possibly to far removed from effective positions.
- Result: NOTHING!

Run #2

- Like Run #1 except this time using an aluminum coated bottom roller.
- Result: Like Run #1.

Run #3

- Like Run #1 except this time using a Teflon tape coated top roller and sanding out the inside of the gazing ball.
- Result: More frustration.

Run #4 and #5

- Like Run #3 except this time using different belt materials.
- For Run #4 panty hose belt.
- For Run #5 Dr. Stewart's poncho.
- Results: WHY WON'T THIS WORK?!

Run #6, #7, and #8

- Runs with panty hose, poncho, and shower curtain belts respectively.
- Using a 100% Nylon panty hose coating about 8 layers thick.
- Results: More of the same.

Run #9, #10, and #11

- Exactly like Runs #6-8 except with braided wire to replace suspect combs.
- Results: More ways to not make a working Van de Graaff.

Run #12

- Using stranded wire, shower curtain belt, and newly made glass roller on the bottom.
- Result: A faint spark onto a nearby knuckle.

Run #13

- Run #12 redux
- Result: nothing

Run #14 and #15

- Like Run #12 but with poncho and caution tape belt material, and with previously made combs.
- Results: Shattered self-esteem.

Runs #1 through #11 could all be easily dismissed as being poor choices of roller materials. The thought that a positive roller could be coated with Teflon tape lead to the belief that the opposite could be true; using aluminum and Nylon coatings on the bottom roller. However from many different trials it would seem that that is not necessarily the case.

So trying to actually consider the triboelectric series the bottom coated roller was replaced by an indisputably positive roller, glass. On the first run with the new roller using the first belt material there was a faint spark to the knuckle, which was not felt again. With hope welling up changes in the belt and using the original comb, which had a greater spacing set at a seemingly more favorable position, were made with no charge being felt.

Things that are confirmed to be fine with the Van de Graaff: the glass roller and Teflon tape coated roller combination, contact between top comb and gazing ball (for both the stranded wire and soldered comb), ground, and the general construction of everything not important to making a Van de Graaff work or not work.

Things that are unconfirmed: use of belt materials, comb placement, which comb to use (if either are any good), and whether or not there is any charge leaking from the gazing ball.

Possible improvements: more belt materials, better spread stranded wire (as it is the comb that has worked), and "sealing" any leaks of charge with either a ring of copper pipe or a lot of electrical tape as seen in many other Van de Graaff honors projects.

Conclusion

Through the process of making this Van de Graaff many things were learned about how important preparation is in build projects. Also much was learned in the physics behind how a Van de Graaff and other electrostatic devices work. Eventually the non-working Van de Graaff will become just the Van de Graaff, but unfortunately it will probably not happen during the course of this project.

Sources

http://www.arborsci.com/Vandegraaff/Van_de_graaf_generator.jpg

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