John B. Johnston, The Faraday Center, 103 Creamery Rd., Livingston Manor, NY 12758
(845) 439 - 4706

The Van de Graaff generator - is probably the most popular piece of physics apparatus ever developed because of its exceptional educational and entertainment value. First, a little history about it. Van de Graaff developed it as part of his PhD thesis at Princeton Univ. He actually built two; one is at the Smithsonian in Wash. D.C. and the other remains at Princeton. The Princeton Physics Dept. has refurbished theirs and built a replica to duplicate the original, matched pair, one negative, one positve. Of course, Van de Graaff went on to M.I.T. where he built the largest pair in the world. They had a brief research life as particle accelerators. He and/or M.I.T. donated the pair to the Boston Science Museum where they can be seen as the center piece of the greatest man-made lightning show on earth. When in Boston, take the time to see it; you will never forget it!

Warning! To be on the safe side, do not operate the Van de Graaff or its system near any computer or computer-like device.

The generator's use is limited only by one's imagination. Here is but a brief collection of my favorite demonstrations that use it. For even more demos that can be performed with it, see "The Wimshurst machine" elsewhere on this website; the Van de can excite (power) each of them with ease. Be careful, however, not to overpower them.

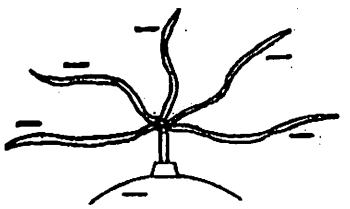
For all of these demos, I use the very popular WINSCO* N-100E with its 25 cm dome. Generally, the larger the dome, the greater the capacitance (charge storage) and potential (voltage). The charge on the dome is always negative.
I have modified mine slightly by adding a banana plug jack (terminal) near the base of the dome for an easy (better?) connection to accessories. Also, I have carefully drilled some ventilation holes in the lower cabinet, top and bottom, near the motor to let the heat out during operation.
* WINSCO is the logo for the Wabash Instrument Corp. of Wabash, IN. wwwwinsco.com

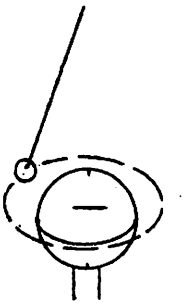
For a discharge electrode of equal size (25 cm dome), I was able to salvage a discarded Welch Van de. I also added a banana plug jack near the base of its dome for easy grounding. Thus, I have a matched pair to work with.

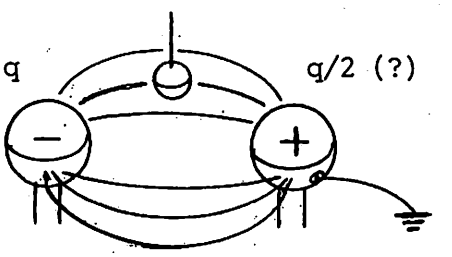
The "collection" of demonstrations:

1. The "hair thing" is undoubtedly the most popular demo performed with the Van de. It uses the dome's large negative charge (many electrons) to charge up the strands of hair. Because like charges repel, each charged strand repels the other or moves as far apart as possible, thus spreading out. However, to achieve the best result with the most hair standing up and spreading out the most, a few rules should be followed.
   First, if possible, use a girl with natural blond hair.
   Second, ask her to wash and dry her hair before coming to school.
   Third, ask her to use no creme rinse. She will be reluctant to do this. However, for science, you have to hope she will be a good sport about it.
   Fourth, she must stand on a well-insulated platform** with one hand on the dome before starting up the Van de. While charging up, have her shake her head occasionally to loosen her hair. At full power, the effect should be at its best. Then she must keep her hand on the dome as the power is reduced and finally turned off to avoid an uncomfortable shock. Then she can remove her hand from the dome and step off the platform undisturbed.
   ** An upside down, heavy, 3½ gal. plastic utility bucket (from the biology dept.?) makes an excellent insulated stand.

   Lesser alternatives are possible. Being "hair-challenged", I went to a novelty store around Halloween and was able to purchase a blond, synthetic wig that actually performed very well. (My students will never forget it!)
   Often, because of electrostatic demos, a cat or rabbit fur pelt is available to be placed on the dome. The fur will stand up very well when charged.
   Another alternative on the same theme is the "electric plume" which is a suction cup with several ribbons attached. Placed on top of the dome, they will rise up and spread out when charged. To work well, however, the ribbons need to be narrow, a ¼" wide or less. Use shears to cut wider ribbons down to the narrower size. (Double the number of ribbons?!)

1. 

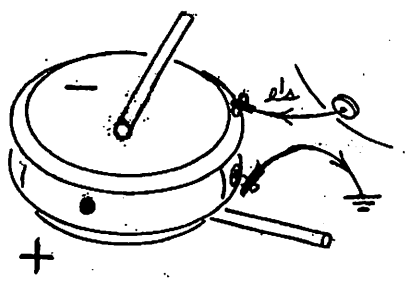
2. 

3. 

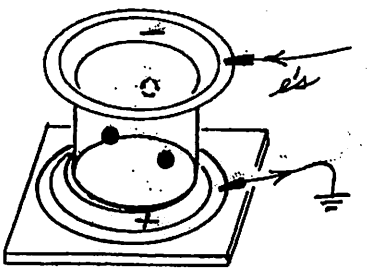
2. Less dramatic but more educational are the demos on the electric field lines around a charged dome. These lines can be demonstrated (investigated) in a number of ways, starting with a graphite-coated styrofoam sphere on a nylon thread 2 ft. long hanging from a wooden stick (dowel?) 2 ft. long. You might prefer a graphite-coated ping pong ball on the end of the thread instead. Allow the charged sphere hanging from above to circle the dome demonstrating an equal-potential line perdendicular to the electric field lines; the geometry is interesting.
In recent times, confetti, puffed rice, soap bubles, etc. have been used to fly off the charged dome to demonstrate the presence of the invisible electric field lines and their direction(s). But is the "mess" that is left to clean up worth it? You decide.

3. Let's introduce the second, unpowered, dome (the discharge electrode) into the demonstration. It can be made negative by contact or positive by induction (being grounded). Again, the electric field, its lines, around and between the domes can be investigated by the sphere on the stick. With practice and imagination, you can "trace" out the lines reasonably well. Keep in mind that, as a "rule of thumb", the positive charge on the second dome of equal size will be roughly half of that on the first dome when being charged by induction via the first dome. Thus, the electric field between the two domes will be skewed, not symmetrical.

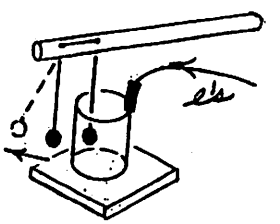
4. As previously mentioned, any of the demonstrations performed by the Wimshurst machine can be powered by the Van de and its strong negative charge (source of electrons). The positive side of each demo will be charged by induction via grounding. Simply attach a wire lead with a banana plug to the jack at the base of the Van de's dome and the other end with an alligator clip to the accessory's negative side. Attach a second wire lead with an alligator clip to the accessory's positive side and the other end with an alligator clip to a ground. Three popular demos from "the Wimshurst machine" are illustrated.

4. 

Franklin's "jumping jacks"

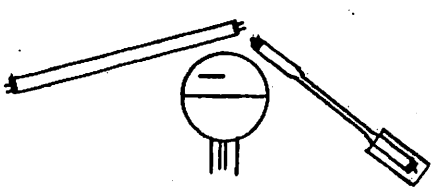


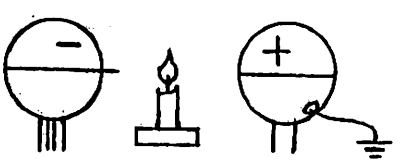
Volta's "hailstorm"

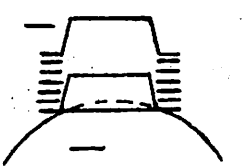


Faraday's "ice pail"

5. The Van de's strong field can be utilized to power various gas tubes such as fluorescent, neon, CFL lamps, etc. Experiment. Change distances from the dome and observe changes in field strength. Roughly demonstrates the inverse square rule and Coulomb's Law? Of course, the large dome is not a point source which is the ideal.

5. 

6. 

7. 

6. The "electron wind" is a very interesting demo that helps explain why electricity (electrons) take the path of least resistance or the most ions (good conductors). Bend a paperclip so one prong sticks straight out from the dome; with masking tape, attach the rest of the clip to the dome. Place the second dome, with its ground, opposite the first dome. Place a candle flame in between on an insulated stand. Start up the Van de,and watch the flame with its ions bend toward the positive dome, aiding the transfer of electrons coming off the paperclip's "point" over to the positive dome. The electron "leak" (conduction) off the first dome is so efficient that no sizable charge build-up on the dome can occur, thus no spark can happen. You have witnessed what a lightning rod does and what Ben Franklin realized in 1750!

7. Fun and games. Still utilizing the rule that like charges repel, place a stack (at least 6) of inexpensive aluminum pie or tart pans on the top of the dome; attach the bottom pan to the dome with masking tape. Start up the Van de and observe the result. Now have a short-haired boy stand on the insulated platform with his hand on the dome. Place the stack of pans on his head and start up the Van de. Same result as before?

Beware! The one great drawback of the Van de compared to the Wimshurst machine is the Van de's belt. Its proper maintenance will always be a problem. Even getting the belt on and off the pulleys is not an easy task. First, you have to carefully remove the top half of the dome to get at the top pulley. Then you have to remove screws to open up the bottom cabinet to get at the bottom pulley. Turn the Van de upside down. Just before handling the belt, wash and dry your hands thoroughly; perspiration causes rapid deterioration. Keep the handling to a minimum. Place the belt on the bottom pulley first and draw the rest of the belt up through the clear plastic tube. I fashioned a "hook" by bending (distorting) a dry cleaner's coat hanger. Turn the Van de right side up and pull the belt up to the top pulley. With the belt near the top pulley, carefully (without tearing) transfer the belt to the top pulley, straighten out any wrinkles, and place the pulley in its axle slots. For both bottom and top, be careful not to allow the belt to touch the sharp points of the wire combs that would cause tears in the belt. Reattach the bottom cabinet and the top half of the dome. Test the assembled Van de to see that the belt is running smoothly.

Here is the part that is seldom discussed, its storage for nearly a year between uses. Many years of experience have taught me a number of things about Van de belts. When your demos with the Van de are concluded, immediately remove the belt, and place it in a cool, slightly damp place for next year (next use). Belts deteriorate rapidly when stretched and are left in warm, dry places. Even then, with the best of care, belts will age and lose their efficiency at transporting electrons from the bottom to the top. You may find it wise to order a new belt on a set time schedule, i.e., every 2,3, or 4 years, so you and your students are not disappointed due to a bad belt. When you buy a new belts(s), keep the original envelope and write down the date you receive it on the envelope. Also, storage areas get very dusty in a year's time. Try to keep the Van de as dust-free as possible; cover it up, especially the dome. Always clean the dome thoroughly before use.

My experience with my WINSCO has been excellent for over 30 years. They are still in business and have on hand any replacement part you might need to keep their Van de going; their parts list is on their website.

Note: I have no professional or financial connection with WINSCO. For any part, I use my VISA card like anyone else. They simply have a quality product that is very reliable and very repairable (but seldom required).