Hand Crank Van de Graaff Generator

P6-3400

INSTRUCTIONAL GUIDE

Contents

Hand Crank Van de Graaff Generator:

- Dome and base
- 16” discharge electrode
- Discharge electrode hook-up wire (red)
- Electric Whirl
- Belt (P6-3401)
- Drive belt (P6-3402)

Recommended for Activity:

- Neon Wand (P6-3360)

Introduction

This Van de Graaf Generator is cranked by hand to demonstrate the effects of static electricity. Because you control the amount of electricity produced depending upon how hard and how long you crank, this is a true "hands-on" experience for younger students. The Van de Graaf Generator deposits a large amount of positive electrical charges on the metallic dome. This huge volume of positive charges produces spectacular effects!

When two insulators are rubbed together, one loses electrons to the other and becomes electrically positive. It has acquired positive electrical charges. The other insulator, having gained excess electrons (negative electrical charges) becomes electrically negative. These charges are static because they do not move on their own. Walking on a carpet in a dry room with dry feet deposits a large amount of electrical charge on your body; the impact is felt when you touch a door knob. Electrical charges can also be induced on a neighboring insulator or conductor by induction. In the case of a flat insulator, the opposite side acquires opposite electrical charge by induction.

Background

The generator uses a plastic pulley at the lower end of the machine, attached to a hand crank. A rubber belt passes over the pulley. As the pulley turns, rubbing occurs; the pulley acquires negative charges while the inside surface of the rubber belt (near the plastic pulley) acquires an equal amount of positive charge. The outside surface of the belt acquires an equal amount of negative charge by induction. An electrode (comb or brush) is provided to drain away these negative charges from the outside surface of the rubber belt to the "ground."

A similar comb (electrode) is provided at the upper end where it provides a path taking positive charges to the collector dome. The plastic pulley retains the negative charges that it acquired.

Positive charges stay on the inside surface of the belt and travel upwards on the belt. At the top, it runs over a metallic pulley which picks up these positive charges and retains them. Free electrons from the

metallic pulley flow on the electron-deficient belt and are carried down to the plastic pulley. As the belt keeps running, more charges are deposited on both pulleys, resulting in heavy buildup of charges on each. Soon this buildup reaches ionization intensity in the vicinity of the two combs and a large number of positive and negative charges are generated. Positive charges are transferred to the dome by the upper comb, and negative charges are drained to the **ground** by the lower comb. The belt transports negative charges from upper to lower comb and positive charges (on the other half of the belt) from lower to upper comb.

Once on the metal dome, the positive charges spread out due to **electrostatic repulsion** and become uniformly distributed because of the dome's spherical shape. The buildup of positive charge on the dome continues until ionization intensity is reached. This is the **equilibrium state** and limits the quantity of charge that the generator can place on its dome. It is measured in **volts.**

Once this limit is reached, the air between dome and base gets ionized and a discharge with spark occurs. The discharge causes the potential to fall below the ionization intensity but is brought up to the limit again in seconds, and another similar discharge occurs. The process continues as long as the generator is running.

Assembly

For Additional help please watch the assembly video at https://youtu.be/7mqfAjrkaMI

1. Locate the hand crank sub-assembly (Figure 1)

Figure 1

2. Loosen the two screws on the base of the main assembly to allow the slots in the hand crank sub-assembly support to slide under the screw heads and washers (Figure 2)

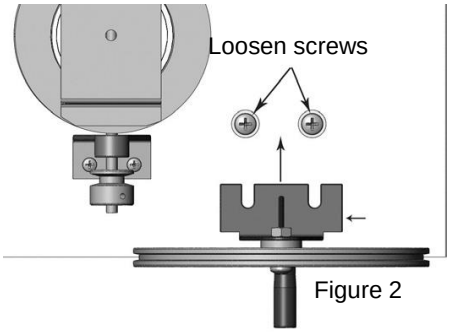

Figure 2

3. Align the large and small pulley so the belt will run true. Tighten the screws to hold the crank assembly in place. Stretch the drive belt over the pulleys (Figure 3).

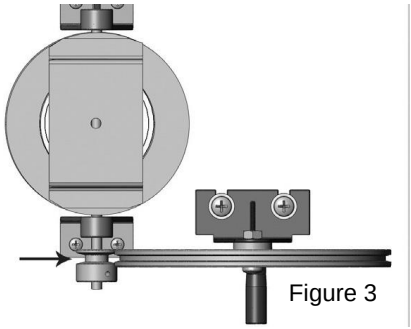

Figure 3

4. Stretch the pulley belt over the tube and clip into place. Insert the top roller of the pulley belt into the pulley collector mounting assembly part. (Figure 4 – Figure 7)

Figure 4

Figure 5

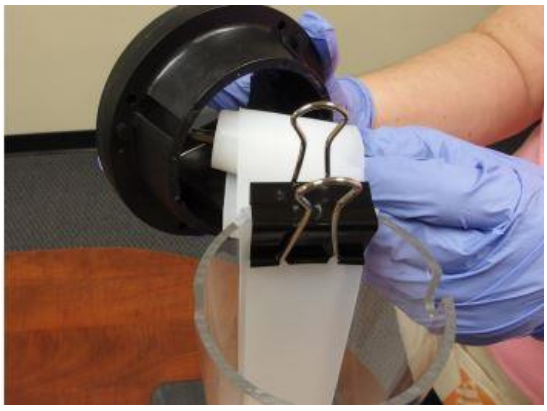

Figure 6

Figure 7

5. Unclip the belt, and place pulley collector mounting asssembly part on top of the tube. Confirm the upper roller is inserted into the notches and the pulley belt is centered on the roller. (Figure 8 – Figure 9)

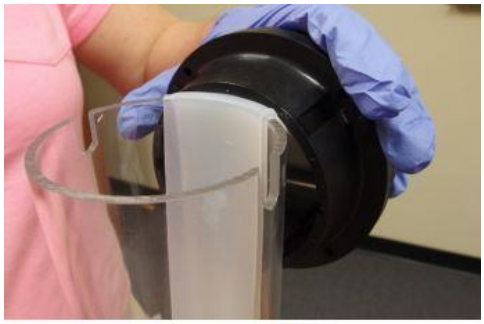

Figure 8

Figure 9

6. Locate the collector support shaft and screw it into the top of the upper brush/pulley bracket on the main assembly (Figure 10).

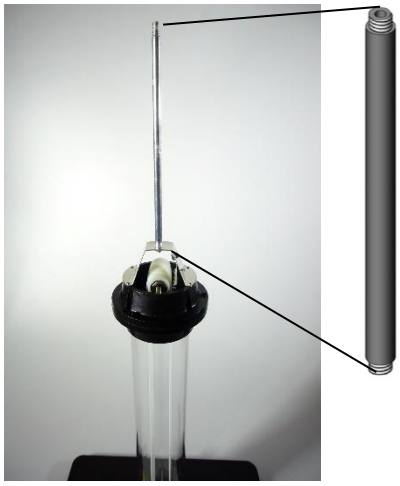

Figure 10

7. Place the collector on top of the support, making sure the threaded portion of the support is protruding from the small hole at the top of the collector (Figure 11)

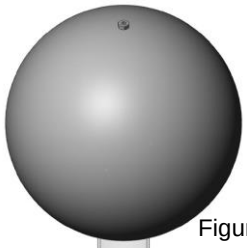

Figure 11

Activities

Hair Raising:
Approaching a running generator can be a hair-raising experience. This is because the charges are transferred to your body, especially to the hair. Due to electrostatic repulsion between similar charges, every hair tends to get as far away from every other hair as possible. This “raises” hair and can be felt on head, arms and all over the body.

For best results you need two people and a plastic footstool. Stand on the footstool and place one hand palm down on the globe of the Van de Graaf before your helper turns the crank. Keep your hand on the globe, with your other hand at your side taking care not to touch anything else, the entire time the machine is running. Shake your hair lightly to loosen the strands; wait 1 - 2 minutes.

You should now feel each individual strand start to lift. Have your helper angle a mirror (taking care not to get too close!) so you can see. Fine, light, long hair works best. Make sure you do not remove your hand from the globe, touch anyone or step down from the footstool while the machine is running. If you do, you will feel a mild shock. This is because, by doing so, you have completed the electrical connection and grounded yourself. (The footstool serves as an insulator.) The static electricity, instead of remaining on your body, passes to earth.

This experiment works best on days when humidity is low. Water vapor drains static charge.

Electric Wind:
Charge distribution on the collector dome is isotropic because the dome is predominantly spherical in shape. The distribution will not be isotropic for irregularly or asymmetrically shaped objects.

This is because narrower parts always carry much greater concentration of charges than broader parts. The effect would be maximum for pointed objects like thin rods or large needles.

Try attaching a conductor in the form of a sturdy, light, thin metallic rod six to eight inches long (for instance, a darning needle) on the body of the collector dome, radially outwards. Use tape or clay to attach. The concentration of charges at the tip of the needle will be so intense that it will ionize air in its neighborhood. Negative ions will rush towards the collector dome and neutralize their charges. Positive ions, however, move away (due to electrostatic repulsion) from the generator and do not get neutralized. As the generator is continuously running, it keeps supplying more and more positive ions at

a fast speed. The ions running away form a wind called “electric wind” which blows away (radially outward) from the generator. By attaching the conductor or needle, you have created an electric wind.

Use the Electric Whirl to demonstrate electric wind. When set on top of the Van de Graaff, the Whirl discharges positive ions into the air and begins to spin rapidly.

St. Elmo’s Fire:
Electrical discharges from clouds to earth are 3 different types.

a. **Point Discharge:** No visible light or sound. Point discharges are responsible for most discharge between clouds and ground.

b. **Corona Discharge:** Visible light but no audible sound - known as St. Elmo’s Fire.

c. **Lightning Discharge:** Blinding light and deafening sound.

You can create St. Elmo’s Fire in a darkened room by attaching a small, thin sewing needle firmly against the collector, radially outwards perpendicularly. Install it correctly by using a drinking straw or small plastic strip. Tape the needle to one end of the plastic straw. Hold the straw by the other end and press it lightly against the collector dome to avoid a shock as you approach the dome with your hand. A small but significant glow or fire appears at the tip of the needle.
St. Elmo’s Fire can also be created by attaching a 3' long electrical wire (not solid, but stranded) to the eye of a sewing needle. As the strands are passed across the eye, fold and twist them with pliers to join the needle solidly to the wire’s end. Connect the other end of this wire to the ground connector on the base of your Van de Graaf. (This procedure will not work if your receptacle has only two flat holes.) Now tie the needle perpendicularly to one end of a drinking straw using cord or tape. Hold far end of straw and bring needle close to the collector dome to watch the “fire” glow. With this method, you can study the effect of distance on the glow. The glow will be stronger in the vicinity of the dome. As distance increases, the glow dims.

Lighting:
You can light a variety of light emitting devices with your Van de Graaf Generator - for example, incandescent (filament) light bulbs, fluorescent tubes or lamps, gas filled tubes, old radio tubes, even tiny neon tubes. For best results, do these experiments in a darkened room or at night.

Bring your bulb toward the collector dome as the generator is operating. You may wish to make some sort of nonconducting holder for your light bulb to avoid receiving a shock as you approach the collector dome. The outside glass surface nearest the dome acquires negative charge by induction. The charge builds up on the glass surface to discharge intensity. As discharge occurs, negative charges rush through the entire bulb, lighting it up for the duration of the discharge.

Experiment with distances between bulb and dome. The bulb will light even when 12 inches away from the dome. Here, discharges will be stronger but the intervals between them will be longer. The light bulb will also glow more brightly. When you bring the bulb nearer, the discharges are more frequent but the light is dimmer. If you touch the dome with the bulb, the light may be continuous (or flickering) but the intensity will be low.

Household (incandescent) bulbs will glow with purple light. Other gas-filled tubes will glow with the characteristic lights of the respective gases.

Related Products

Electrostatic High-Voltage Genecon (P6-2640) This hands-on alternative to traditional “Van de Graaff” generators allows electrical discharge experiments to be performed in the classroom with far greater ease and less cost. Gently turn the handle to generate more than 10,000V of high voltage static electricity!

Deluxe Van de Graaff Generator (P6-3300) Generator provides power for all basic electrostatic experiments on a dramatic scale, with sparks of 8" to as high as 12" to 15". Yet with a maximum continuous current of just 10 microamps, it's quite safe for classroom use.

Friction Rod Kit (P6-1600) Explore charging by friction, positive and negative charge, and attraction and repulsion with the friction rod kit. Includes glass and hard rubber rod, silk and faux fur pads, bubble wrap, glass rod mounted on pivot needle, and complete instructions.