

VAN DE GRAAFF GENERATOR

The Van de Graaff generator is a device which produces and stores a large electrostatic charge on a metal dome.

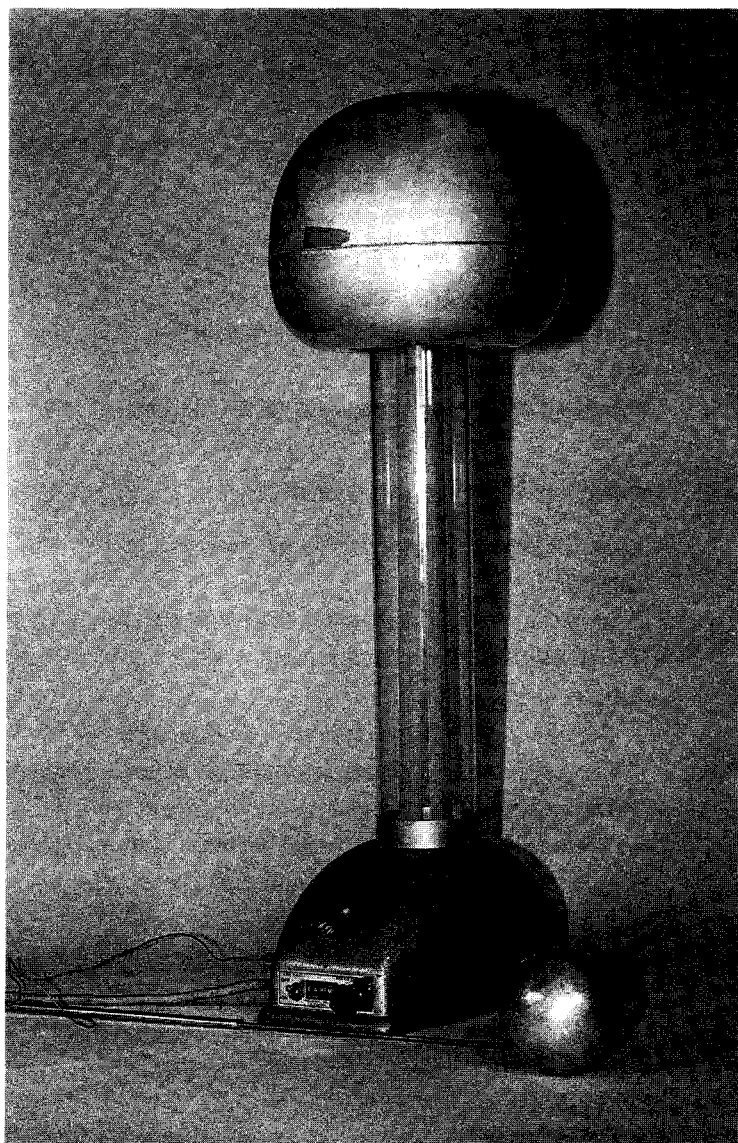
It discharges to a smaller sphere and, in ideal conditions, it can produce a voltage of 400,000 volts with a short circuit current of 20 micro-amps.

It can be used to demonstrate the presence and nature of electric fields and the functioning of the Van de Graaff Accelerator.

SAFETY

PRECAUTIONS

- ⌋ Take off all *metal jewellery* before handling the machine.
- ⌋ Check that the discharging sphere is *always* the closest thing to the charged dome.
- ⌋ Always hold the discharge sphere support rod by its insulating handle.
- ⌋ Be careful not to touch the metal base of the machine when it is running.
- ⌋ When switching off the machine, it is safer to use the switch at the power point.
- ⌋ After switching off at the power point, always ensure the spheres touch together to earth the main dome before touching the machine with your hand.
- ⌋ Though the Van de Graaff operates at high voltage, its low current assures that it is **HARMLESS**. Nevertheless, a shock from it can be quite unpleasant.



SETTING UP AND USING THE VAN DE GRAAFF

C It is worth checking the following items before setting up an experiment

- ⌋ *The functioning of this equipment is heavily dependent on weather conditions* The electrostatic charge leaks away rapidly to water molecules and dust particles in the air. Hence the equipment works most efficiently on a dry windy day.

- Set up the Van de Graaff at least 1.5 metres away from walls, light fittings, plumbing etc.
- Arrange to be in a laboratory which can be blackened out with heavy blinds or in a large dark room. In this way, the full array of the discharging spark can be seen.

X Extra equipment for the suggested learning experiences (numbers refer to appropriate experiences) includes:

- clean dry cloth
- sticky tape (2,4)
- a perspex and ebonite rod and a piece of silk and flannel (2)
- small pieces of paper (2)
- a wig, or one made from long strips of paper or wool attached to the top half of pantyhose (2)
- 4 petri dishes (4)
- paraffin oil or baby oil (4)
- a beaker of small grass seeds eg. couch (4)
- tin foil or metal hooks (4)
- 2 long leads with alligator clips attached (4)
- an overhead projector (4)
- a large foam ball suspended on a nylon thread (2)

S Setting up the Van de Graaff

•Wipe the dome, the sphere and the perspex column with a clean dry cloth to remove any dust particles.

•Plug in the machine and, using the black knob on the base, adjust the speed to a maximum.

•Touch the dome with the discharging sphere and build up the capability of the machine in the following manner:-

- Position the discharge sphere just a few millimetres away from the charging dome and wait till there is a regular steady discharge of approximately one per sec.
- Increase the distance and repeat the procedure.
- The rate of discharge is a better indicator of the performance of the machine than the optimum voltage, because the optimum voltage is affected so greatly by the conditions of the atmosphere.
- Leave the machine running, discharging regularly as described above, for 5 - 10 minutes before doing any experiments.

HANDY HINTS

The performance of the Van de Graaff improves with frequent use.

Dry out the rods, cloth and wig in the oven before use.

On humid days, while the machine is warming up, leave on a radiator close by.

SUGGESTED LEARNING EXPERIENCES

Topic - Electrostatics

1. Develop the concepts of charge, current and voltage.

This is a set of experiences to motivate students and familiarise them with the concepts of static charge being built up on an object and voltage being a measure of the electric potential energy.

•Darken the room.

•Observe the intensity of the spark as the spark gap changes -the bigger the gap, the more energy

- is required for the discharge to occur, and therefore the bigger the voltage.
- Observe the intensity of the spark as the speed of the motor is changed.
- Observe the intensity of the spark and the change in the motor speed as the charge is allowed to build up over time – it gets harder for the charge to be received by the dome.
- Turn the machine off at the power point and observe the discharge.

2. Discover the interactions between like and unlike charges.

This is a set of learning experiences to demonstrate the nature of the electrostatic force and the presence of the electric field.

- Leave the charge to build up on the dome and allow students to experience the electrostatic pull on the discharge sphere as it is held about 10cm from the dome. Also experience the push of the repulsive force as the dome discharges. Repeat at different distances and at various charging times.
- While the machine is turned off, fasten a wig, or a collection of small strips of paper on to the dome. Turn on the machine and observe the repulsion of the similarly charged strands of hair or paper. Discharge the dome and note the effect.
- Alternatively, encourage students with long, fine hair to stand close to the Van de Graaff while it is charging. Do not stand closer than the discharge sphere.
- Charge a large foam ball connected to a long nylon thread by touching it with a charged ebonite rod. Suspend the ball close to the dome of the Van de Graaff and observe the effect. Repeat using a perspex rod and determine the type of charge produced on the dome.
- Keeping the discharge sphere at the maximum range (10-15cm), drop a handful of small pieces of paper between the dome and the sphere and observe the behaviour of the paper. This is powerful evidence for the presence of an electric field.

3. Develop the concept of ionisation.

- Darken the room. Demonstrate the corona effect from the pointed end of the discharge rod as the surrounding air particles become ionised.

4. Clarify the nature of electric fields.

Use the Van de Graaff generator as a high voltage source of electricity to map the electric field around differently shaped electrodes. See *Exp. 9.4 in Essential Physics or Exp E.5 in Senior Physics Year 11 for details of the procedure of the experiment.*

- connect the stripped end of a wire to the dome with sticky tape.
- disconnect the discharging sphere and use this earth wire to connect to the other electrode.
- place a petri dishes with oil in them on the overhead projector so that all students can see the results clearly.
- sprinkle the seeds into the petri dish *just before you* start the demonstration as the seeds will absorb the oil and eventually sink to the bottom.

Topic - Nuclear Physics

5. Discover the principle of the functioning of the Van de Graaff Accelerator.

Take the Van de Graaff generator apart and show students how it works. Explain similarities to the accelerator.