VAN DE GRAAFF GENERATOR
Article Code: QLL014

Description

Useful for electrostatics experiments, where continuous source of high voltage is needed. A motor driven assembly encased in a sturdy metal box made of specially designed two part aluminium extrusion with insulated plastic side supports for safety. The motor driven lower roller rotates the upper roller assembly located on top of the insulated Perspex pipe through a removable flat rubber belt. The continuous rotation of rubber belt results in accumulation of charge on the one piece near spherical metallic dome, charge being transferred continuously from rubber belt through charge collecting combs. Specially designed dome, with smooth and polished surface free of any surface imperfections, and without any sharp corner or edge to minimize charge leakage. The motor operates on AC mains 220-240V, 50/60Hz, fused input through a 3-Core mains cable. Provided with indicator type ON/OFF switch. On bringing earthed discharge sphere, sufficiently close to the charged dome, transfer of charge from dome to the ground takes place in the form of electric spark jumping from dome to the discharge sphere. Under favorable conditions, it can develop electric potential upto 200kV, with a spark of upto 70mm length. 4mm socket terminal provided at the bottom for earthing and another 4mm insert on top of the dome for charge transfer or attaching accessories.

Provides for necessary adjustment in all the critical components. Supplied complete with discharge sphere, mounted on a long insulated.

Experiment 1: To study the production of electric discharge using Van de Graaff generator.

Components Required

- Van de Graaff generator
- Discharger

Theory

Van de Graaff generator

The American physicist, Dr. Robert Jemison Van de Graaff invented the Van de Graaff generator in 1931. The device has the ability to produce extremely high voltages - as high as 20 million volts. Van de Graaff invented the generator to supply the high energy needed for early particle accelerators. These accelerators are known as atom smashers because they accelerates the sub atomic particles to very high speeds and then "smash" them in to the target atoms. The resulting collision creates other sub atomic particles and high energy radiations such as X-rays. The ability to create these high energy collisions is the foundation of particle and nuclear physics.

Conductors and Insulators

- Atoms are made of a nucleus formed from protons (positive charge) and neutrons (neutral charge) surrounded by orbiting electrons (negative charge).
- Most materials have an equal number of protons and electrons and are electrically neutral.
- When electrons are not tied to the nucleus (or are loosely bound), they may move through the material.
- How easily they can move from one end to the other depends on whether the material is an insulator or conductor.
- In conductors, electrons can move freely, whereas in insulators they cannot.

Ionization

- The Van de Graaff generator also demonstrates ionization of air ionization occurs when the electric field strength becomes strong enough to strip electrons from atoms in the surrounding air.
- When the electrons recombine with the positive ions in new combinations, visible light is released.

Principle

Corona discharge: A corona discharge is an electrical discharge brought on by the ionization of a fluid such as air surrounding a conductor that is electrically charged. Spontaneous corona discharges occur naturally in high-voltage. A corona will occur when the strength (potential gradient) of the electric field around a conductor is high enough to form a conductive region, but not high enough to cause electrical breakdown or arcing to nearby objects.

If the charged conductor is brought into internal contact with a hollow conductor, all of its charge transfers to the surface of the hollow conductor no matter how high the potential of the latter.

Theory

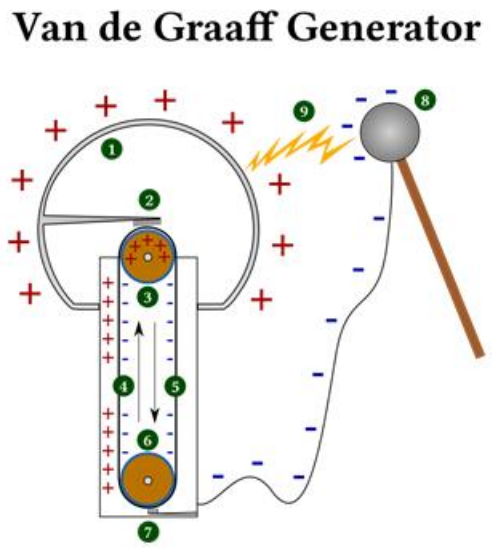
Let us consider a large spherical shell of radius R. If we place a charge of magnitude Q on such a sphere, the charge will spread uniformly over the surface of the sphere and the electric field inside the sphere will be equal to zero, and that outside the sphere will be due to the charge Q placed at the centre of the sphere.

So the potential outside is that of a point charge; and inside it is constant, namely the value at the radius R. We thus have:

Potential inside conducting spherical shell of radius R carrying charge Q = constant and is given by,

$$\mathbf{V = \frac{1}{4\pi\epsilon_o}\frac{Q}{R}}$$

Construction



1. Hollow Metal Sphere
2. Upper electrode
3. Upper roller
4. Side of the belt with positive charge
5. Opposite side of the with positive charge
6. Lower roller
7. Lower electrode
8. Spherical device with negative charge
9. Spark produce by the difference of potentials

In the figure given above, we can see a Van de Graaff generator. Here,

- A large spherical shell is held at a height of several metres above the ground supported by an insulating column.
- Two pulleys are wound with a belt like insulating material, with one being at ground level and the other one at the centre of the shell.
- This belt undertakes a continuous motion, thus carrying a positive charge continuously from the ground to the top.
- This belt is kept moving continuously by a motor driving the lower pulley.
- The positive charge is transferred to the larger shell by a carbon brush, thus rendering the outer shell with a very high potential over the time.

Procedure:

1. Connect the main lead to the socket fitted on the apparatus and plug to the main socket 220 V AC mains 50Hz.
2. Connect the one end of a banana plug connecting lead to the discharger and another point to the green color earthing socket.
3. Turn the switch on.
4. Rubber belt will start rotating.
5. The belt rotate with the same speed throughout the experiment.
6. Take the discharger nearer to the dome fitted on the Van de Graaff generator. It will generate an electric spark.

Note: Discharge the Van De Graff by touching the discharger with the dome before switching off otherwise one can get electric shock. Do this every time when use the Van De Graff generator.

Experiment 2: To demonstrate that like charges repel each other using head of hair and Van De Graff Generator.

Components Required:

- Head of hair
- Van de Graff generator
- Discharger Dome with connecting lead

Theory

The head of hair was created to show how insulators can become conductors with the help of an electric charge. It also demonstrates how like charges repel each other. When generator is on the same charge is transferred to the each strand of the accessory to show phenomena of repulsion of the opposite charges.

Procedure

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Insert the head of hair in the socket on top of the dome.
3. Connect the discharge dome with earthing socket using connecting lead.
4. Switch on the device.
5. Operating the generator makes the hairs acquire similar charge repelling each other resulting in spreading out and away from the dome, finally standing straight up.

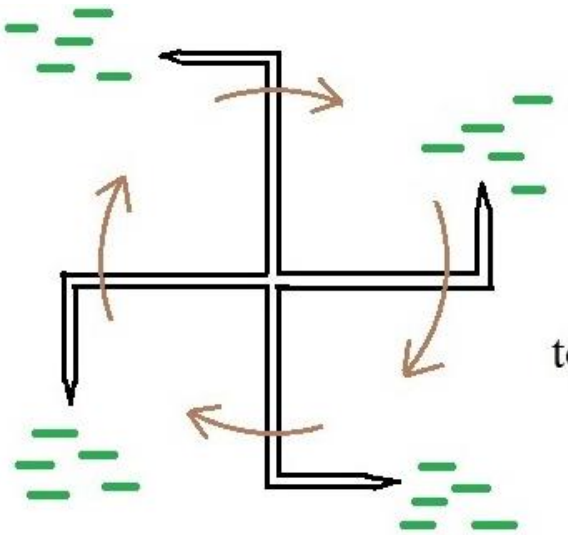
Experiment 3: Demonstration of the spinning of the electric whirl by the effect of the Van De Graff Generator.

Component Required

- Electric whirl
- Van de Graff Generator
- Discharger Dome with connecting lead

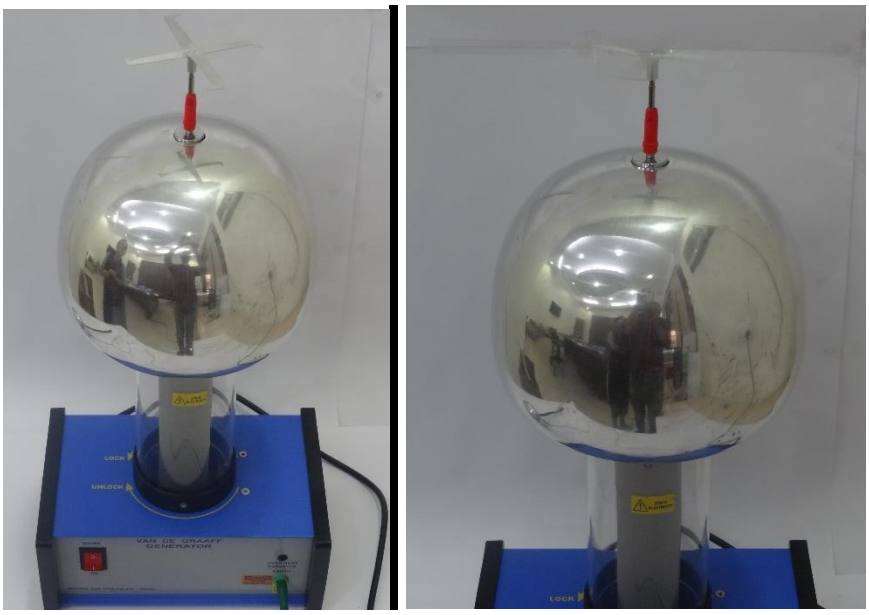
Theory

The electric whirl spins due to the torque created ions propelled out the tips of the spokes. We assume the Van de Graaff generator dome and the whirl are negatively charged in this sketch. The points at the ends of the arms will "throw off" negative charge. The negatively charged arms will be repulsed by the negative cloud of space charge near the ends of the arms and the whirl will spin as shown.



Procedure

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Connect the discharge dome with earthing socket using connecting lead.
3. Connect the electric whirl with the dome of the Van De Graff generator.
4. Switch on the device.
5. The electric whirl start rotating.



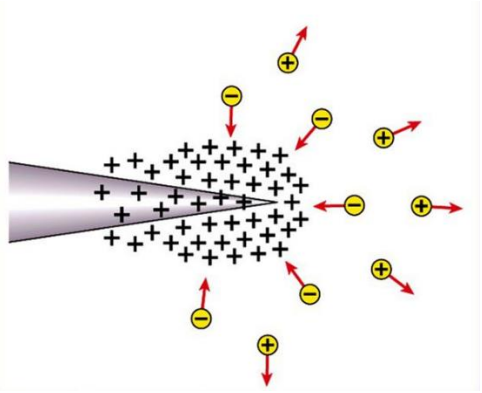
Experiment 4: Demonstrate the phenomenon of electric wind using point discharger.

Components Required

- Point discharger
- Van de Graff Generator
- Discharger Dome with connecting lead

Producing electric wind

A sharp point on a charged conductor has a higher surface charge density which will generate a stronger electric field. The strong electric field ionizes the air molecules surrounding the sharp point, and those ions or electrons which have charge opposite to that of the conductor will be attracted towards the sharp point, while those ions or electrons with the same charge will be repelled. This phenomenon is called the point effect. The moving ions drag air molecules into motion, producing an electric wind that can turn a mini-windmill.



Procedure

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Connect the discharge dome with earthing socket using connecting lead.
3. Connect point discharger on the top of the dome.
4. Switch on the device.
5. A strong electric field is generated near the sharp point.

Experiment 5: To study the effect of the Van De Graff on the Volta's Hailstorm.

Components Required

- Volta's Hailstorm
- Van De Graff Generator
- Connecting leads

Theory

In Volta's Hailstorm, attraction and repulsion effects are demonstrated. The effects occur upon induced charges when the bodies used are conductors and have a path to ground to get rid of the repelled charge. They occur upon dipoles or poles of higher order when there is no path to ground or the bodies are nonconductors. Sometimes the dampness of the atmosphere renders dielectrics (non-conductors) slightly conducting and the effects are due to a combination of causes. The particles in the Vermiculite are repelled from the metallic base because they pick their charge from it. Upon losing it on the upper plate they fall due to gravity. They are also repelled from the upper plate if they stick long enough to pick up a new charge.

Procedure:

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Attach the Volta's hailstorm on the top socket of the Van De Graff Generator.
3. Switch on the device.
4. The pith balls placed on the lower surface get the similar charge and repelled.
5. The balls strike on the upper surface and lose its charge and fall down due to effect of gravity.

Experiment 6: To determine the charge conduction using neon bulb.

Components Required

- Neon Bulb
- Van de graff generator
- Discharger dome with connecting lead

Theory

The neon bulb can be used as an alternative electroscope to determine electric charge. When one electrode of the bulb is brought into contact with an object that is charged, a flash occurs. The neon bulb contains two electrodes in a space filled with neon gas. The light inside the neon bulb occurs nearest the negatively charged electrode (or cathode). If the electrode nearest the object that is touched is the one that flashes, then the object was negatively charged. If the other cathode lights up, then the object was positively charged, and the electrons flowed in the opposite direction.

Procedure

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Switch on the device.

3. Now take a neon bulb near to the Van de Graaff's dome the neon bulb light up according to the charge on the Van de graff generator's dome.

Experiment 7: To study the interaction between pith balls using van De Graff generator.

Components Required

- Pith Balls on rod
- Van de Graaff generator
- Discharger dome with connecting lead

Procedure

1. Connect the main lead to the socket fitted on the Van De Graff generator and plug to the main socket 220 V AC mains 50Hz.
2. Attach the pith ball on rod at the top of the dome using 4mm socket.
3. Now switch on the device.
4. Both the balls first attract each other.
5. Then ball are charges with same charge and as a result they start repelling each other.

Precautions

- Always switch off the supply before making any adjustments to the apparatus.
- The Van de Graff generator like all electrostatic apparatus should be kept clean and dry.
- Discharge the dome after use to avoid shocks.
- Use a soft duster to clean dome, sphere and rollers

Applications of static electricity in daily life

There many applications of static electricity in daily life, including photocopying, electrostatic precipitator and electrostatic spraying. Besides, knowing more about static electricity can help us to prevent possible hazards. For example, a vehicle carrying inflammable materials has an iron chain attached to its rear; this transfers charge to the ground to prevent fire caused by sparks. For the same reason, since oxygen and inflammable an aesthetic are often used in a hospital, the floor of an

operating room is usually anti-static, and all the instruments have to be grounded. This prevents explosion caused by sparks.