Discharging Phenomena by Using Aluminum Collecting Spheres

NaRiKa Corporation

1. Learning Outcome

In this sub-unit, we make experiments of "Spark Discharge" using the Static Genecon and Aluminum Collecting Spheres. Learning outcome of this sub-unit is for students to be able to explain about the Discharging Phenomenon.

2. Introduction of various types of Discharges

[1] Dark Discharge:

If high voltage is applied to two of electrodes, electric field appears between those electrodes. Then, if radioactive ray (including natural radiation) strikes the electric field, discharging phenomenon, namely "Dark Discharge", occurs. Spark Chamber is the apparatus to observe natural radiation based on the "Dark Discharge" phenomenon.

[2] Spark Discharge:

Spark Discharge is the phenomenon of electrons transferred between two electrodes in a discontinuous manner when insulation breakdown occurs after high voltage is kept impressed to two electrodes and the voltage reaches a tipping point. Electrostatic discharging phenomenon that occurs when human fingers touch metallic doorknob is seen as Spark Discharge.

[3] Corona Discharge:

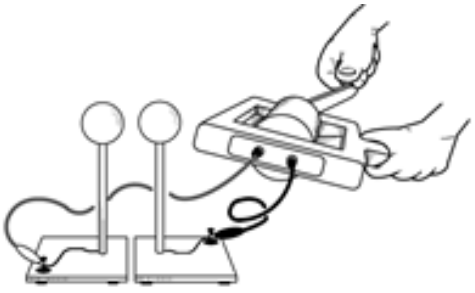
Also, known as "Point Discharge" that is the continuous discharge from sharp and pointed electrode. The name of "Corona Discharge" is derived from the emission at the discharging point that resembles solar corona.

[4] Glow Discharge:

Discharging phenomenon that persists in the low-pressure gas. Type of the gas encapsulated in discharge tube determines the color of emission. If the amount of current carried is increased, Glow Discharge migrates to Arc Discharge.

[5] Arc Discharge:

Release of electrons known as the final shape of discharge. Applied in lights like fluorescent lamp and arc welding.



Van de Graaff generator is normally used for discharging experiment that generates very high voltage of 100,000 V - 150,000 V. Since it is pretty costly, Van de Graaff generator is mainly used for teachers' demonstration at schools. In this sub-unit, instead, we are going to use the "Static Genecon" in combination with the "Aluminum Collecting

Spheres" for students' group experiment in order to secure students' safety and better experimental effect based on the low voltage electromotance of Static Genecon.

3. Electrostatic Generator: "Static Genecon"

We already know that if we rub piece of plastic with felt or different kind of cloth then static electricity will be generated. And we have in various ways confirmed properties of above mentioned way of generating static electricity. As a result, we have learned among other things as well, that electrostatic charge has two kinds. Furthermore, we can store static electricity because of the invention of Leyden jar and Electrophorus. By using them we can store greater amount of static electricity, thus conducting experiments with large amount of static electricity. Because of that invention research about static electricity accelerated in the past.

In 1929, Robert J. Van de Graaff (1901-1967, USA), with purpose to invent particle accelerator, invented high voltage electrostatic generator, so called:" Van de Graaff generator". Van de Graaff generator can generate low electric current, but it can accumulate high amount of voltage. It is often used for demonstration experiments in schools.

In this unit, we will use "Static Genecon" that generates static electricity continuously in the same way as Van de Graaff generator to perform various experiments. For example: Charge & Discharge, or Repulsion and Attraction experiments, by analysis of the behavior during experiments, let's deepen our understanding of static electricity.

Static Genecon
(Narika B10-1324)

"Static Genecon", developed by NARIKA Corporation, is a smaller version of Van de Graaff generator. Below you can find a simple explanation of the operating principle. The basic principle is: by rubbing two things against each other, static electricity is generated.

In drawings below, we can see simplified internal structure of Static Genecon. Felt reinforced with metallic copper is in contact with drum made of PVC. Also, to collect electricity charge generated on the surface of the PVC drum, there is a collector made of metal (Figure 1).

If you rotate slowly the handle of Static Genecon, PVC drum will rotate, and rub felt. As a result of the friction, on the surface of PVC drum negative charge, and on the felt positive charge will be generated. On the surface of nonconductor static electricity will not move, therefore when PVC drum is rotated, negatively charged static electricity formed on the surface of PVC drum is transferred to the collecting plate.

Because collecting plate and PVC drum are not in contact, due to negative charge on the surface

of PVC drum, collecting plate will be induced and negative electric charge on the surface of PVC drum will be neutralized. Because of the electrostatic induction of collecting plate, negative charge will easily move inside the conductor. On the other hand, positive charge generated on the surface of felt will be supplied by negative charge from metallic copper plate inside of the felt, therefore it will be electrically neutralized (seemingly it looks like transference of positive charge. See Figure 2 and Figure 3.).

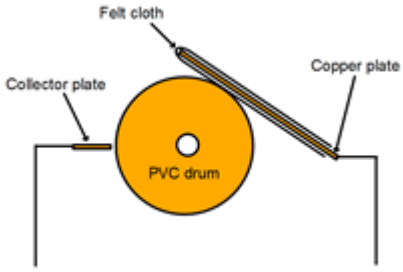


Figure1

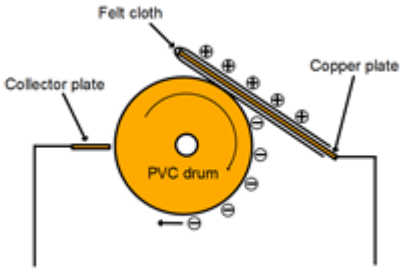


Figure2

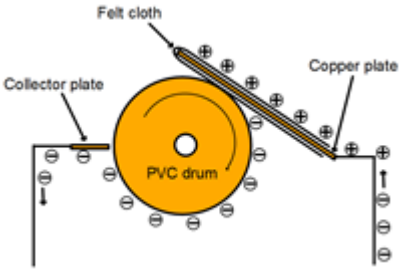


Figure3

4. Discharging Phenomena by Using Aluminum Collecting Spheres

There are various kinds of discharges, such as, Dark Discharge, Spark discharge, Corona Discharge, Glow Discharge, Arc Discharge and others. In this sub-unit, we will create spark discharge by using Static Genecon and Aluminum Collecting Spheres.

1. What to prepare

- Static Genecon: 1 pc (Narika B10-1324)
- Aluminum Collecting Sphere: 2 pcs (Narika B10-1324-03)

Static Genecon
(Narika B10-1324-W0)

Aluminum Collecting Sphere
(Narika B10-1324-03)

2. Experiment procedure

1) To the red terminal of Static Genecon, connect included red cable, and to the black terminal black cable.

2) Connect red cable from Static Genecon to terminal of one Aluminum Collecting Sphere as shown in the drawing below.

3) Connect black cable from Static Genecon to terminal of the other Aluminum Collecting Sphere as shown in the drawing below.

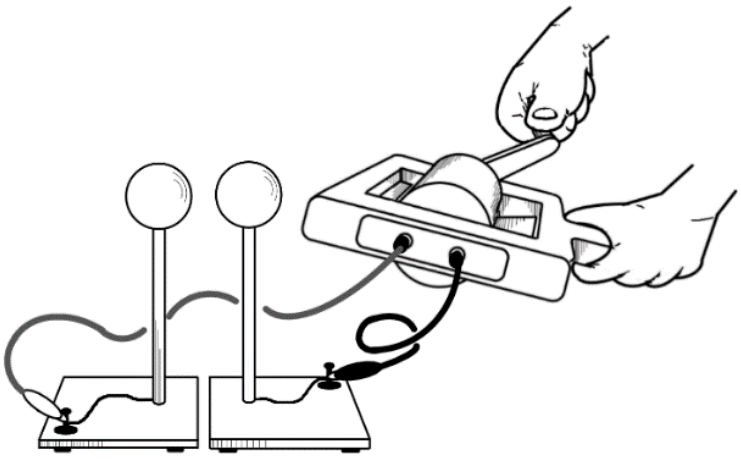
4) Keep the distance between the two spheres around 5 mm.

4) Slowly turn the handle of Static Genecon (it can be clockwise or counterclockwise).

5) After turning the handle for a while, there will be spark generated between the spheres.

6) If discharge phenomenon does not occur between the spheres, please do the following:

i) Make the distance between spheres smaller.
ii) Remove dust collected on the surface of the spheres.



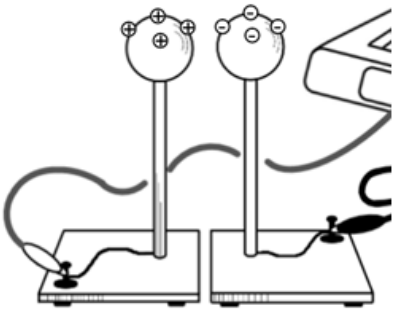
5. Question

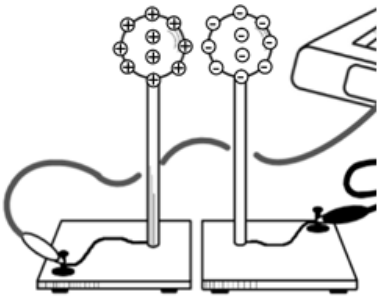
1. Observe discharging phenomenon between the two Aluminum collecting Spheres. Please describe the mechanism by which the Aluminum Collecting Spheres discharge.

1) Positive (+) and negative (-) charge is stored on the surface of the two of the Aluminum Collecting Spheres when static electricity is transferred from Static Genecon.

2) Normally the static electricity is not carried through air that works as insulating material between the spheres.

3) However, insulation breakdown occurs, and electrical charge is emitted through the air after the charge stored on the sphere reaches a tipping point.





2. Depending on the distance between the Aluminum collecting spheres, there are cases where discharge occurs and cases where discharge does not occur. Please think about the reason why is this happening and explain about it below.

Insulation breakdown (in the air) mentioned above determines the occurrence of (spark) discharge between the Aluminum Collecting Spheres. Aside from the factors including distance between two spheres, superficial area of the sphere, or voltage impressed to the electrodes, occurrence of Insulation Breakdown depends on the distance between two of the Aluminum Collecting Spheres. Hence, (spark) discharge happens after the occurrence of Insulation Breakdown in the air with the voltage of 1,000 V impressed between 1 mm-spaced spheres, 2,000 V impressed between 2 mm-spaced spheres, and 5,000 V impressed between 5 mm-spaced spheres. This way, voltage impressed during the discharge is predictable based on the measured distance between the two spheres.

Since Static Genecon generates up to 10,000 V, theoretical maximum distance between the spheres to generate spark discharge should be 10 mm under the ideal conditions. If the spheres are placed in the distance of more than 10 mm, electrical leakage happens from the spheres

surface due to continuous Corona Discharge.

Corona Discharge is also known as “Point Discharge” that is the continuous discharge from sharp and pointed electrode. Even though Aluminum Sphere does not have any “sharp point”, instead of Spark Discharge, Corona Discharge could happen from the “point” made by dust accumulated on the surface of the sphere.

This is why keeping cleanliness of the equipment like Static Genecon or Aluminum Collecting Sphere is important for the experiment on static electricity. Also, we have to care about dust that may adhere to the equipment used for experiment.

On the other hand, static electricity has the advantage of attracting dust by the electrostatic induction that is applied to the industrial use of copy machine, dust collector, powdered paint, and so on.