615-3240 (10-005) Electrophorus

Additional Materials Required:

- Metal Electroscope (we recommend our 615-3078)

Warranty, Replacement Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered. We accept Mastercard, Visa, American Express, and school P.Os. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse, or normal wear and tear.

Purpose:

To understand the physics of the electrophorus and to demonstrate the effect of electric stored energy. Proper use of our electrophorus will provide a strong spark repeatedly, without recharging.

Discussion:

The electrophorus has historically been used as a charge dispensing device. It is simply a condenser (which is a capacitor) with dissectible parts. The electrophorus is charged not by an external voltage source. Instead, the insulator separating the conductors is charged through **triboelectrification**.

The electrophorus was originally developed by Johannes Wilcke in 1762. The device was modified and later improved by Allessandro Volta in 1775. Volta actually named the device an electrophorus, and soon thereafter become known as the *perpetual electrophorus*. It was so-called because once the insulator was charged, the electrophorus could seemingly produce an endless quantity of electric charge.

Wilcke reported quite accurately the physics of the electrophorus. However, since they did not have an understanding of atomic theory at that time in history, they did not fully understand the triboelectrification of the insulator, nor why the insulator appeared to hold the charge for such a long period of time.

It has been said that the electrophorus is the electrical analog to a permanent magnet in the way that it permanently keeps its charge. Interestingly, keeping the top plate on the electrophorus preserves its power in an analogous manner as a keeper (or iron rod) placed across the poles of a permanent magnet. All in all, the electrophorus is a wonderful device that played a significant role in the early development of electrostatic theory.

Procedure:

Our electrophorus consists of an aluminum plate lying on a negatively charged PVC surface. In the figure below, the electrophorus is circular in shape, or disk shaped. The insulator of the electrophorus used in our experiments is simply PVC. The metallic disk has an insulating handle attached to its center such that the electrophorus can be dissected without grounding the top plate.

The operation of the electrophorus proceeds as follows: Initially, the top of the insulating PVC plate is briskly rubbed with a piece of cloth (preferably wool, silk, or fur). This will create a static charge on the surface of the insulator through a process known as **triboelectrification.** In this process, the electrons are actually exchanged between the insulator and the cloth through a chemical reaction of the dissimilar materials. The rubbing actually increases the surface area over which the materials make contact, and hence increases the amount of charge distributed on the insulator. The sign of the charge induced will be dependent upon the insulator and the material used to rub it. For sake of argument, let us assume that a positive charge is now distributed on the surface of the insulator.

The metal disk with insulating handle is then placed on top of the charged insulating plate. Negative charges are attracted at the bottom surface of the metal disk by **Coulomb Force**, and positive charges are repelled to the top surface of the metal disk polarizing the disk, as shown in Figure 1.

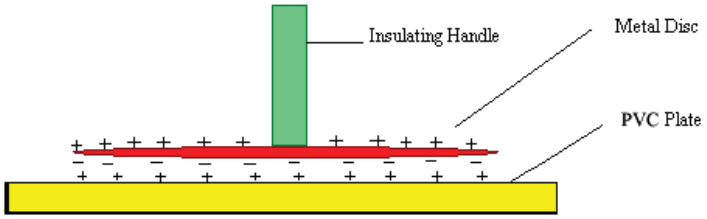

Figure 1: Before Grounding

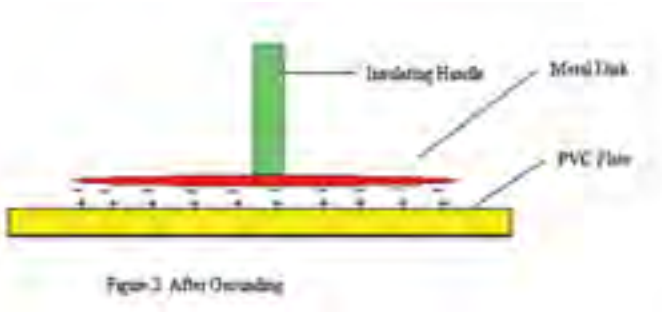

Figure 2: After Grounding

It is noted that the charges in the metal disk are "displaced" by the Coulomb force. The top surface of the metal disk is then grounded by either touching it with a finger or using a direct connection to ground with a conductor. The positive charges will be neutralized while the negative charge remains at the bottom of the metal disk, as shown in Figure 2.
By holding the insulating handle, the metal disk is then removed from the top of the insulator. Once it is removed and is sufficiently far from the PVC plate, the negative charge will distribute itself about the metal disk until an equilibrium is reached (recall equilibrium is established when the net force acting on each charge is zero).

Experiment 1:
One way to show that you have taken a charge from the PVC plate and moved it to the metal plate is to discharge the metal plate. Hold one lead of your neon bulb in your hand and touch the other lead to the metal disk top. The bulb will glow to show there is a charge flowing.

Experiment 2:
Another way to show this is to touch the charged disk to an electroscope. This causes the aluminum leaves to repel from each other. The above procedure is then repeated, but without rubbing the insulator with the cloth or touching the surface. Before repeating these steps, the electroscope and the metal disk are grounded such that they are charge neutral. Then, the disk is placed on top of the insulator, the top is grounded, the disk is removed, and the disk is touched to the electroscope. It is observed that the electroscope leaves are repelled the same distance as in the previous case. In fact, this can be repeated again any is reached (recall equilibrium is established when the net force acting on each charge is zero).

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

615-3240 Electrophorus Concepts: **Triboelectric effect, Electrophorus, Electroscope, Discharge, Capacitor**
Stationary charge.
Curriculum Fit: **Physical Science and Chemical Science/Matter. Science as inquiry.**
Unit: **Observation and Measurement of Physical Properties.**
National Science Education Standards: ***Science as inquiry*; Design and conduct a scientific investigation; Use appropriate tools and techniques to gather, analyze, and interpret data.**
***Physical Science*; Transfer of Energy.**
Benchmarks for Science Literacy: **The Designed World; Section** 8C.4

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