Dissectible Leyden Jar

P6-3380

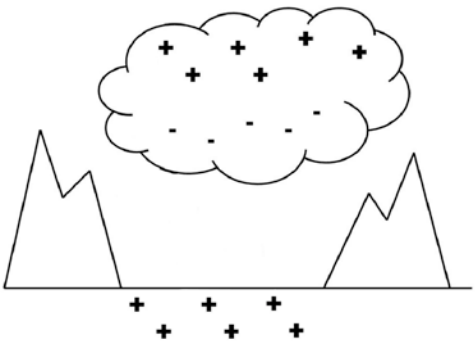
BACKGROUND:

This apparatus is designed to demonstrate the principles of static electricity, the use of a Leyden jar, and to allow the student to investigate and manipulate the electrostatic phenomena.

STATIC ELECTRICITY:

Static electricity has been known for many years, and was one of the first sources of electricity to be investigated. Benjamin Franklin performed his early experiments in electricity with static electricity, and the Leyden jar was developed as a means of storing and accumulating static electricity. With the development of current electricity, static electricity became mostly a matter of historical interest. However, recent developments of liquid crystal displays, medical X-ray imaging, and xerographic copying have revived interest in this phenomena.

The most easily observed electrostatic effect is lightning. Rapidly rising air drags many positive-charged ice crystals to the top of a storm cloud, leaving the bottom of the cloud with a huge excess of negative charge. (The details of the charging process are still not clearly understood.) The negative charges at the base of the cloud induce a local positive charge in the ground and trees below. When the difference in the charge becomes great enough, electrons rush across the gap, heating a narrow column of air until it explodes with light and sound: a bolt of lightning!



An equally common effect, but one which most people do not realize is electrostatic, is the xerographic copier. In this case a special type of material is used, which is non-conducting in darkness but conductive when exposed to light. While in the dark the materials is charged with static electricity. When it is exposed to light the areas exposed lose the charge, while most not exposed retain the charge. After exposure to light the plate is sprayed with a fine powder of oppositely charged dry ink (toner), which adheres to the areas of the plate, which retained a charge by electrostatic attraction. Finally, a sheet of paper, which is also charged is placed on the plate, and the toner is transferred to the paper. The paper is then heated briefly to make the toner adhere

permanently. The excess toner is scraped off the plate, and the entire plate is exposed to light to remove any remaining charge.

THEORY OF STATIC ELECTRICITY

The word “static” as in “Static Electricity” means at rest. This is, however, a misleading name because static electricity does indeed move. The name static electricity differentiates between current electricity, which is produced by using a magnetic field to force the electrons over a conductor. In static electricity, the electrons are physically pushed from one place to another. This causes a temporary uneven distribution of electrons over an object. Because the natural tendency of objects is to remain in a neutral state, the electrons strive to regain that neutral balance in the object by slowly leaking off or quickly jumping to another object with less electrons, which caused a small spark.

The term *conductor* is used to refer to materials that will allow electrons to travel over it easily. Some materials act as better conductors than others, providing an easier path for the electrons. The term *insulator* refers to material that opposes the travel of electrons. A good insulator prevents almost all passage of electrons. The air however, which is usually considered an insulator, can conduct electricity slightly depending on the moisture in the air. This accounts for the fact that electrons can escape from even the best insulators by discharging through the air. The word *electron* comes from the Greek work, which means amber. At the time the Greeks discovered the effects of static electricity by rubbing amber with a cloth. They thought that amber was the only material that exhibited this phenomena. When other materials were discovered that showed similar properties they were referred to as having the amber effect of *electrica*.

It is important to remember when experimenting with static electricity, that like charges repel one another and unlike charges attract one another. The electrons can transfer from one highly charged object to one that is less charged because the higher concentration of negative electrons is attracted to the object that is more positive in state.

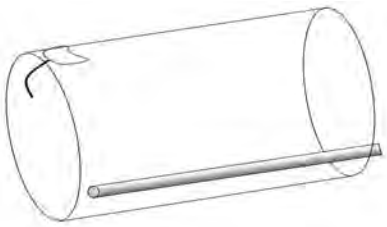
Current electricity is generated by pushing electrons along a conducting media with a magnetic field. Static electricity is a non-moving electric charge. It is created by mechanically moving electrons from one place to another. If some material has free electrons (as most do) they will in general be evenly distributed on the surface along with the positive charges in such a way that the overall charge of the object is neutral. By rubbing two such materials together, however, it is possible to mechanically redistribute the electrons so they are, temporarily, unevenly distributed. When this happens the object has a slight negative charge where the electrons are concentrated. If the two objects have different amounts of free electrons, and since electrons will be transferred to the other object, as long as the two objects are in contact the overall charge will remain neutral. However, when the two objects are separated, one will now have more electrons than it started out with, and the other will have less. This will result in a negative charge on the one with more electrons and a positive charge on the one with less.

This is what happens when you walk across a floor (especially during the winter when there is not enough water in the air to conduct charges).As you walk you slowly transfer electrons from the carpet to your shoes, and the electrons move as far away from the carpet as possible, to your fingers. When you then touch a grounded object (such as a light switch) the electrons move to the switch, so that your body is once again neutral. You get a shock as the electrons jump the gap from your finger to the switch!

THE ELECTROSCOPE:

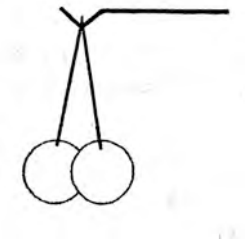
The electroscope is a device used for detecting a difference in electrical potential of an object. The word *scope* means, "to see" and an electroscope is designed to allow you to see the presence or absence of an electrical charge. The electroscope is a good accessory to have when teaching with a Leyden Jar.

To begin with you will need some way to test the electrostatic charges. Usually for this you will use some sort of electroscope. You can use any type or make one using a drinking glass or a beaker and tape cotton thread to it as shown. This cotton thread will act as a simple electroscope. That is it will be used to determine the presence of an electrostatic charge.

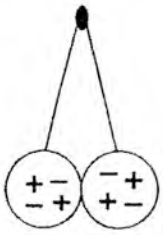


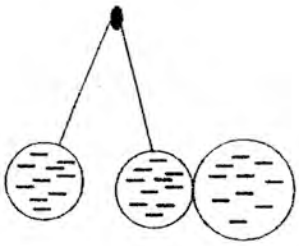
PITH BALL ELECTROSCOPE:

An electroscope works because of the nature of electrons. More simply because opposite charges attract and the same charges repel one another. If an object that is highly charged with negative charged atoms (electrons) is brought near to two aluminum painted cork balls (used to be made from pith), that are hanging side by side, the positive atoms on the balls will be attracted towards that object.



This will cause them to swing in the direction of the object being tested. If the object touches the balls, some of the electrons will be transferred to balls. This makes both balls negatively charged which in turn causes the balls to repel one another. The more negative they are the more they will push each other away. This gives you a visual indication of the strength of the present charge.





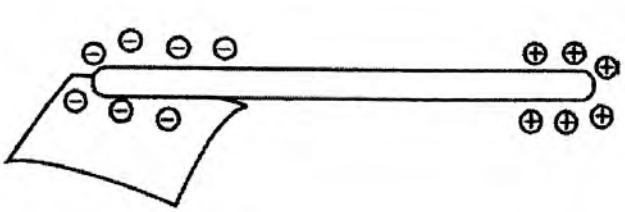
ELECTROSCOPE:

A very common type of electroscope and one that has been around for a long time is the closed case electroscope. This item can be very sensitive and because it is enclosed within a housing, is not prone to being effected by air currents in the room.

Rather than using pith balls or cork balls for indicating the presence of charges, it uses very thin metal foil leaves. Another big difference is the way that the charge is induced on to these leaves. Rather than the object being tested coming in direct contact with the leaves, the charge is introduced to a metal post to which the leaves are attached. The charge is then transferred from the post to the leaves. The foil leaves then act in a similar manner to the cork balls.

LEYDEN JARS:

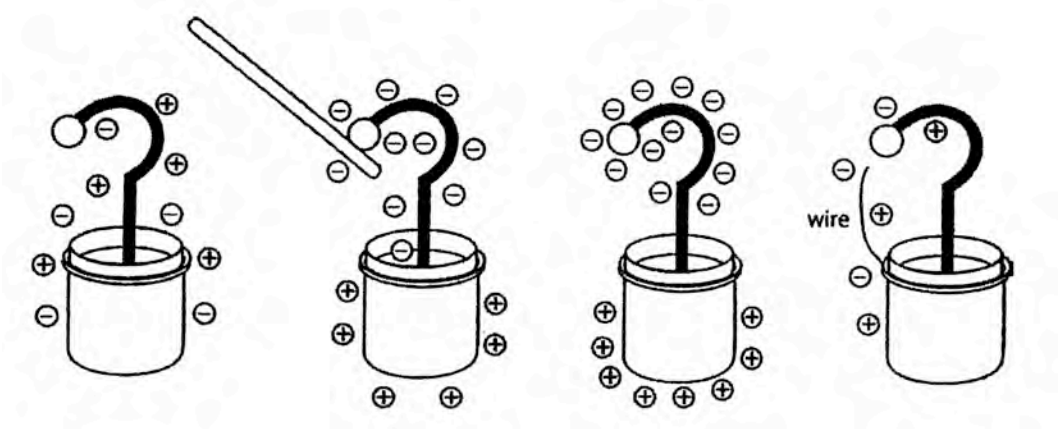
Leyden jars were created during the early phases of the discovery of static electricity as a means for storing a static charge. Leyden jars are capacities. They work almost the same way and the biggest difference being that Leyden jars are designed to hold a static charge capacitors are used more in modern current electricity. Both consist of two or more conducting plates separated by a dielectric. As one plate is charged it forces an opposite charge in the other plate. The greater the potential difference the higher the voltage stored. This potential is determined by the surface area of the plates and the insulator between them. Both plates in an effort to regain a neutral state of charge will try to restore themselves by either jumping across the dielectric or taking an easier path back through a conductor.



Take a look at the illustration of the Leyden jar being charged. The rod first being rubbed with a piece of fur takes on an abundance of electrons from the fur. The rod is then touched to the Leyden jar which takes away some of these electrons. The inside plate has more electrons than it did previously and so the protons are pushed toward the inside of the cup while the excess of electrons are drawn toward the outside cup in an effort to regain a natural state. Repeated rubbing of the rod with the fur and touching the Leyden jar with the rod causes a highly disproportional distribution of positive and negative charged atoms. If left alone, the plates will eventually regain neutrality by either leaking through the insulator or by leaking through the air. However, if a path is created, as in illustration, a spark will occur as the plates find the easiest and quickest route to even out their unequal distribution.

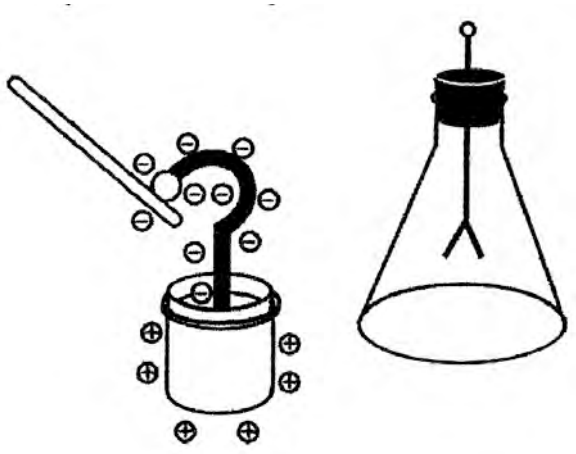
EXPERIMENTS:

In order to become familiar with and to better understand the principles of a Leyden jar you will need a few other items. First you will need something to create a static charge with. There are many different materials that will work. Acrylic rods or sheets, vinyl strips, different plastics and even glass can be rubbed material such as silk, wool, acetate etc. to create static charges. For this experiment we will be using animal fur and a PVC rod however other materials can be substituted. Keep in mind that some will work better than others.



A second item that will be helpful will be any type of electroscope. The type previously mentioned will work as well as electronic and foil electroscopes.

Another item that will really help to educate as well as hold a students attention is a small neon lamp. The type with two wire electrodes and rated around 90 to 120 volts works great. These can be found at most electronic supply stores.



To begin with, place the Leyden jar on a non-metallic table. If you are using an electroscope, have it setting a few feet away. Begin to rub the rod with your materials or fur and after a few strokes touch the rod to the ball of the Leyden jar. Repeat this procedure several times. Now pick up the Leyden jar by holding onto the outside metal surface only. Bring the ball close to your electroscope and notice that the electroscope indicates that a strong charge is present. As you pull the Leyden jar away note that the electroscope also indicates this.

Now grasp the insulator cup being careful not to touch the rod or inside the metal container and lift it up out of the outside of the metal cup. Bring the outside cup close to the electroscope and notice what happens. Move this cup away and bring the ball of the inside cup close to the electroscope. Is there a difference? You should have noted that the ball still elicits a charge on the electroscope even though the outside can is removed. If you will replace the outside can however and bring the ball close to the electroscope you should notice that the charge is greatly increased.

Once again start with the Leyden jar assembled and resting on a non-metallic surface. Rub the rod with the material that you have selected and then charge up the Leyden jar by touching the ball with the rod and then repeating the procedure. You will use a small neon lamp to indicate the charge. After initially charging the jar hold the lamp as indicated in the illustration and touch the wires to the outside can and bring it close to the ball. You should not have to actually touch the ball as a spark should jump from the ball to the electrode and light the lamp briefly. (See image)

RELATED PRODUCTS:

Electroscope (P6-1160)

Friction Rod Kit (P6-1600)

Coated Pith Balls (P6-1650)

Hand Crank Van de Graaff Generator (P6-3400)

Fun Fly Stick Science Kit (11-0051)