Physics II Honors Project

Lyndsy Anderson
Taylor Anderson

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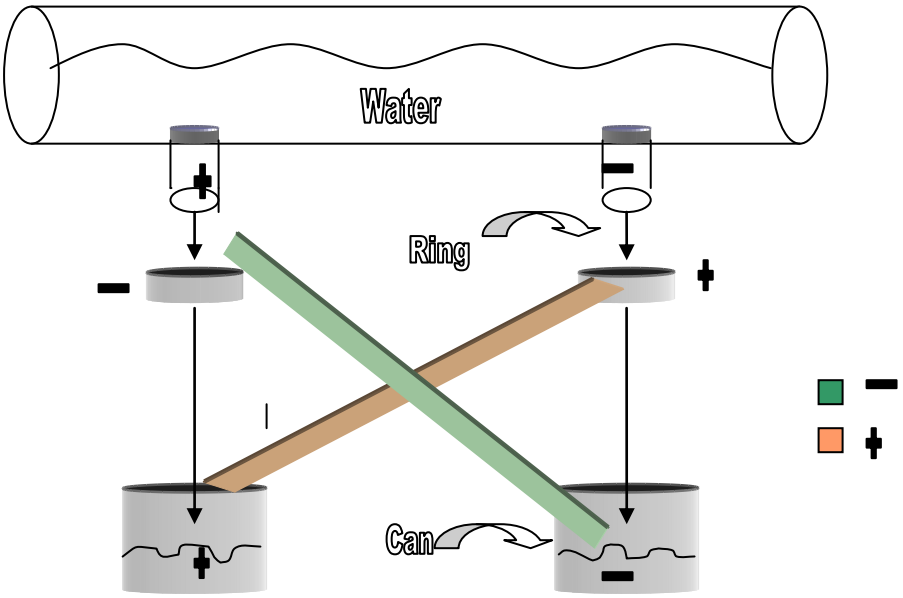
The element of physics chosen to explore in this honors project is that of conducting electricity using an electrostatic generator. This particular electrostatic generator is a water drop system created and designed by a man known as Lord Kelvin.

Lord Kelvin was born William Thomson on June 26, 1824. He was a brilliant British mathematical physicist and engineer who was fascinated by the mathematical analysis of electricity. This fascination led him to study the work of Faraday and conclude that electric induction takes place through an intervening medium or "dielectric". This conclusion in turn led him to creating what is known as the "Lord Kelvin Water Drop Electrostatic Generator" (Weisstein).

The purpose of the "Lord Kelvin Water Drop Electrostatic Generator" is to generate voltage differences by positive feedback, which is defined as some effect causing more of itself. The voltage differences are also generated by electrostatic induction which is the redistribution of electrical charge between interconnected and oppositely charged systems (Beaty).

In the beginning, everything in the system is virtually uncharged. Water is composed of a vast and equal quantity of positive

and negative charges therefore giving it a net electrical charge of zero. The diagram below will help explain how the generator works.



Naturally, some things will be slightly more charged than another. To go along with the drawn diagram, we will say that the bottom left can is slightly more positive than the right can. Therefore, the right can will posses a more negative charge. The right ring will possess a positive charge since it is connected to the positive can. This positive ring will attract the negatively charged ions by electrostatic induction. The negatively charged droplet will then fall from that ring

into the right can which will distribute a negative charge to the right can as well as the left ring. The left ring will then attract the positively charged ions and the positively charged droplets will consequently fall into the left can, distributing its charge and making the can more positively charged. Due to positive feedback, each ring and can becomes more and more charged as the process continues. Having a greater charge means that there will be more effective electrostatic induction. Therefore, this process speed increases as time increases. The electrical energy in the water drop generator is created by the work that gravity does in pulling the charged droplet away from the dripper and toward the attraction of the oppositely charged object (Beaty).

The water should also stream uniformly and the rate of change of potential difference, V, will be proportional V.
This is demonstrated by the equation:

$$\frac{\Delta V}{dt} = KV$$

K is a positive constant depending on construction and water flow details. This equation can then be solved by: $V = V_0 e^{Kt}$ V_0 represents the potential when time equals zero. (Vanderkooy)

If constructed correctly, the build-up of equal and opposite charges on the rings escalates until the potential difference becomes so large that the system needs to discharge. This is seen by a few sparks that will occur between the two oppositely charged rings (Vanderkooy).

In the basic set up there is a support that holds four metal cans that are connected diagonally to each other by two strips of bare wire. It is imperative that the wires do not touch each other and so that they remain isolated in their charge. The two bottom cans also need to be raised above the surface. Above these four collecting cans is another container that holds the water. This container has two holes in it with droppers inserted. These droppers are positioned inside the upper cans so that the spot where the water drops break apart is inside the can (Beaty).

During construction of the the project a series of trial and error attempts occured to decide the best way to construct the project. The conductivity needed to be just right in order to generate a spark from the water dripping through the copper wire. The materials used consisted of copper wire, a wooden spool, three aluminum cans, paraffin, iv tubing, putty, and water.

We embarked on the process of construction by finding a suitable base for the aluminum cans to sit on. A wooden spool was decided to be the main base and used to construct the water drop generator. On top of the spool one aluminum can was set on top. The biggest dilemma we found ourselves facing was finding a way in which to remove the water from the top can and be able to control the drip to the bottom can. During the construction process water tubing and drippers was tried to suction the water out and to control the water flow by using clothespins as a clamp. This design proved to fail because no water was able to drip from the top can down to the bottom can. The next attempt involved using IV tubing and a dripper. Using these materials, water was able to travel from the top can, through the tubes, and drop through the copper wire. Needless to say, the second design proved to be more successful.

The aluminum can was placed in the middle of the wooden spool. Then one hole was drilled on each side of the can near the bottom as possible. Then the iv tubing was placed in the hole and the hole was sealed with putty all around it in order to keep the water flow in the iv tubing and not out of the can. The iv tubing is connected to a

dripper which controls the flow of water. The dripper can be adjusted to a quick drip or a slow drip. A slow steady drip was used when testing the water flow. The top can was filled with water and the dripper was turned to a steady flow. As the tubing was open all the way and the dripper set the water began exiting the top can and entered into the cans below. The water can then be turned off by setting the dripper to an off position and the water no longer flows out of the can.

The bottom of the wooden spool was used as the support for the other two aluminum cans. The paraffin was placed underneath each aluminum can and set on the wooden spool. The purpose of the paraffin is to act as an insulator on the cans in order to receive the best spark as possible. The copper wiring was formed around each can and tightened in order for it to stay on the can. As the copper wire was wrapped around the can the other end was formed into a ring so that the water from the dripper could drip through the copper ring and into the aluminum can. The left can and copper wire was placed underneath the right dripper, and thus the water dripped from the top can through the copper wire connected by the bottom left can and into

the right can. The right can was hooked up in a very similar manner. The copper wire was formed around the can and the other end was formed into a ring. The right can was then placed so that the water from the left side would drip through the right ring and into the bottom left can.

After the two bottom cans were placed so the rings were opposite each other the dripper then needed to be set. The end of the iv tubing was placed through two holes in the wooden spool and then had to be formed so that it would be directly over the two bottom aluminum cans. The setup looks like the following picture:

This picture demonstrates the final set up for the Lord Kelvin electrostatic water drop generator. The next step is to turn the water dripper on and see what happens. The following photo is a close up of the water dripping from the tubing through the copper wire and into the can below:

Of course the first run through generated no sparks, so an attempt to add a little more conductivity was tried. More aluminum was placed around the top can in order to generate a little more conductivity. Wire was also placed inside the iv tubing to see if this

would have any effect on generated a spark as the water dripped through the copper tubing. After these changes were made, the iv dripper was turned on for a second time, and nothing happened. This was using regular tap water. Then bottled water was used as another attempt to generate a spark but nothing came of that and the final attempt was using some natural spring water, which also proved to have no effect as the water exited the top can and dripped into the bottom cans. The water had no effect so our design had to change slightly by adding another can on top of the wooden spool and making it so that one dripper was on each can separately while still having the cans hooked together on top. But even with this design nothing came of the water flowing through the copper wire.

Analysis of the experiment show that the spark emitted from the positive and negative charges never occurred. Possible explanations would be the distance that the tubing was away from the copper wire. The charge could not have been able to change or flow because the water was not close enough therefore keeping it at the same charge it started with in the top can. Also, there could not be enough static charge in the air to be able to help out the charge flowing from one side to the other within the water. The base being a wooden spool

might also have been a problem. Most sources used wood as a base however it might have acted as too much of a conductor causing the charge to have some problems.

This endeavor proved to be more challenging than we first thought it to be. There were many more problems than assumed. From getting the water to drip from the can to getting the copper rings to charge was difficult. However, despite the fact that our project was not successful, we feel that we gained significant knowledge by attempting to build this "Lord Kelvin Electrostatic Generator."

Works Cited

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