Physics Assignment on Applications of Electrostatics

GRADE 10 C

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Table of contents

Acknowledgement 3

Introduction 4

Application of electrostatics 5

Van de Graaff Generator 5

Xerography 7

laser printer 8

Smoke Precipitators and Electrostatic Air Cleaning 9

InkJet Printers and Electrostatic Painting 11

Summary and References 15

Acknowledgement

First and foremost, we would like to praise and thank God, the Almighty, who has granted us countless blessings, knowledge, and opportunity to us. Secondly, we would like to thank our Physics teacher, Tr. Aron, for giving us the opportunity to work on this assignment. Last but not least, we would like to thank our families and friends for their kind cooperation, support, and encouragement which helped us a lot in completing this assignment.

Introduction

As we all know, the area of physics known as electrostatics studies the behavior and characteristics of electrical charges that are static or moving slowly. Coulomb's law, which describes electrostatic phenomena, states that they are caused by the force of charges acting on one another. The charge quickly achieves its equilibrium location because of how strongly the electric force is acting. We can determine electric fields and potential distributions from known configurations of charges, conductors, and insulators using electrostatics' mathematical techniques. On the other hand, if we have a set of conductors with known potentials, we can calculate the electric field in the space between them and figure out how the charges are distributed on their surfaces. It is possible to think of the electrical energy of a group of charges as the work necessary to keep them all together when they are at rest. The electric field that is produced by this build-up of charge can also be thought of as having energy. A capacitor is the last possible energy storage device. Such a device stores electrostatic energy in the electric field, which is equivalent to the energy needed to charge it. Some electrostatic applications are discussed in this assignment, along with their uses.

Applications of electrostatics

Electrostatic research has been proven in many fields. This assignment covers just a few of the many electrostatic applications.

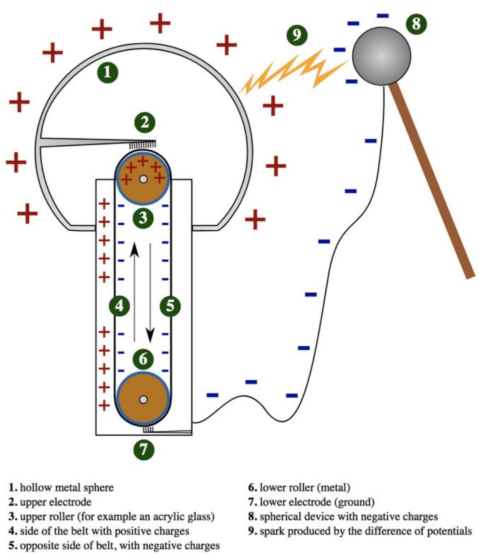
1. The Van de Graaff Generator

Van de Graaff generators are commonly seen in science museums or on television. You are aware of why your hair stands up, but do you understand how it really happens?

It is based on the fact that like charges repel. Van de Graaff generators extract electrons from the Earth, move them along belts, and store them in large spheres. These electrons repel each other and try to separate as much as possible by spreading over the surface of the sphere. Since the Earth has enough space for electrons to spread out, they follow all available paths back to the ground. A grounding rod is a small ball attached to the ground by a wire. It provides a convenient pathway for electrons to move to the ground.

The Van de Graaff Generator is a lot like rubbing balloons in your hair, but instead of balloons, there's a big rubber band in the middle and some rollers and brushes on the top and bottom of the device helps you swap the charges back and forth. When turned on, you may hear or see the rubber band rolling up and down against the roller and brush. It then accumulates a rather strong charge in this ball, on top of the device. when we bring the ground rod close we can see these sparks or hear cracking - these are charges jumping in the air and this tells us that we have a charge of tens of thousands of Voltage. we can also consider the repulsion of positive and positive or negative and negative by placing a conductor(Al) on top we will get the same charge through the whole system - ball and conductor and the conductor will be repulsed.

Van de Graaff Generator



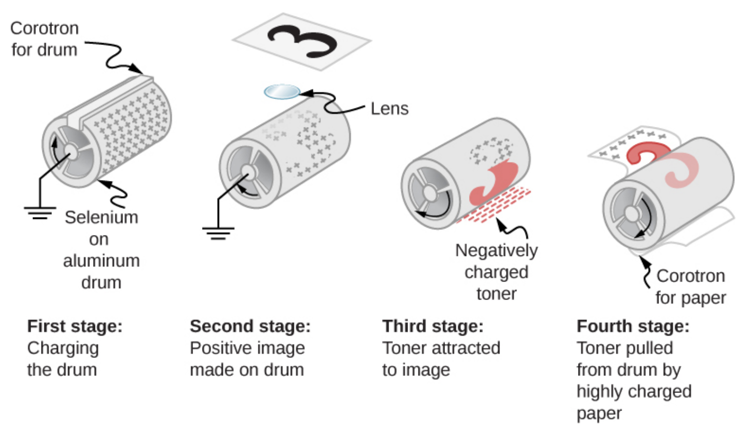
In order to create and employ high voltages for use in nuclear physics experiments, Dr. Robert J. Van De Graff created the first Van de Graff Generator in the United States of America (USA) in 1931. The largest air-insulated Van de Graaff generator in the world was created and constructed by Dr. Robert J. Van De Graff, a professor at the renowned Massachusetts Institute of Technology in the United States, for use in X-ray experiments and atom-smashing research. The original Van De Graaff generator was later utilized for educational and research reasons as new ways t accelerate atoms came into being.
The largest Van De Graff Generator was constructed in an unused dock in South Dartmouth, Massachusetts. A simple Van de Graff generator consists of the following:-

- Metal sphere as the output terminal
- Rollers, two in number
- Brush, two in number
- motor-to turn the belt at a constant speed around the two rollers
- Insulated belt

In modern times, the application of the Van De Graff generator is largely limited to academic purposes to demonstrate practical aspects and concepts of the electrostatic behavior of particles. Designed primarily as a particle accelerator, the Van De Graaff generator is intended for laboratory use only for demonstration purposes. It should be noted, however,t the Van de Graaff generator was one of the first methods used to study nuclear physics before the emergence of better methods for particle acceleration. Although the use of Van De Graaff generators is limited in today's world, they mark a very important milestone in the study of particles in the history of nuclear physics.

2. Xerography

Xerography (Electrophotography) is simply a printing method. Xerography is used to make copies of images or documents and is the printing process used in copiers. Most copiers use an electrostatic process called xerography, a word derived from the Greek xeros meaning dry, and graphos meaning to write.



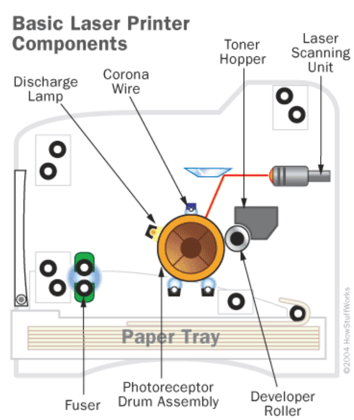
First stage: A selenium-coated aluminum drum is sprayed with positive charges from points on a device called a corotron. Selenium is a substance with an interesting property: it is a photo-conductor. In other words, selenium is an insulator when in the dark and a conductor when exposed to light. Then the conductive aluminum drum is grounded so that a negative charge is generated under a thin layer of uniformly positively charged selenium.
Second stage: The surface of the drum is exposed in the image of what will be copied. Where the image is light, the selenium becomes conductive and the positive charge is neutralized. In the dark area, the positive charge remained and thus the

image was transferred to the drum.
Third stage: Requires a dry black powder, called toner powder, to spray with a negative charge so that it is attracted to the positive regions of the drum. A blank sheet of paper is then given a higher positive charge than the drum so that it draws the toner from the drum.
Forth stage: The paper and toner (electrostatically held) are passed through heated pressure rollers, causing the toner to melt and permanently adhere to the paper fibers.

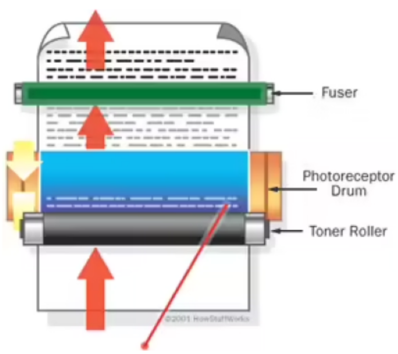
In general, Xerography involves six basic steps; charging, exposure, development, transfer, fusing, and cleaning.

3. laser printer

The main principle that works in laser printers is static electricity, the same energy that causes clothes in the dryer to stick together or lightning to travel from a thunderstorm cloud to the floor. Laser printers use this phenomenon as a kind of "temporary glue". The central component of this system is the photoreceptor, usually a rotating or cylindrical drum. This drum assembly is made of highly photoconductive material that is charged by photons of light.



First, the drum receives a positive charge from the charging corona wire, a wire through which current flows. (Some printers use charged rollers instead of corona wires, but the principle is the same.) As the drum rotates, the printer projects a small laser beam onto the surface to project certain dots. In this way, the laser "draws" the letters, and the image is printed as a pattern of charge - an electrostatic image. The system can also work with reverse charge, that is, a positive electrostatic image on a negative background. After the pattern is set, the printer coats the drum with positively charged toner (a fine, black powder). Since it has a positive charge, the toner will stick to the negatively charged areas of the drum, but not to the positively charged area. It's like writing on a soda can with glue, then rolling it in flour: the flour only sticks to the glued part of the can, so you'll have a message written. With the powder pattern affixed, the drum rolls over a sheet of paper, which is moving along a belt below. Before the paper rolls under the drum, it is negatively charged by the transmission corona wire. This charge is stronger than the negative charge of the electrostatic image, so the paper can pull away the toner powder. Since it moves at the same speed as the drum, the paper accurately captures the image pattern. In order for the paper not to stick to the drum, it will be discharged by the detac corona wire immediately after picking up the powder.



Finally, the printer passes the paper through the fuser, a pair of heated rollers. As the paper passes through these rollers, the loose toner powder melts, fusing with the fibers. The fuser rolls the paper into the output tray and you have the completed page. Of course, the fuser also heats the paper itself, which is why the pages are ALWAYS hot out of the laser printer or copier.

So what keeps paper from burning?
speed - the paper goes through the rollers so fast that it doesn't get too hot.
After putting toner on the paper, the drum surface passes the discharge lamp. This bright light exposes the entire surface of the photoreceptor, erasing the electrical image. The drum surface then passes the charge corona wire, which re-applies the positive charge.

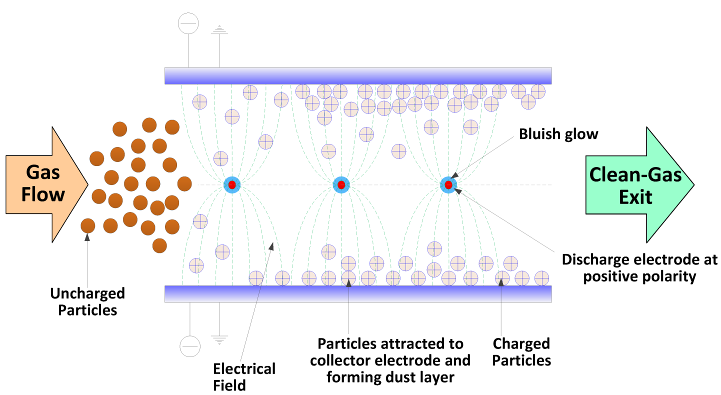
4. Smoke Precipitators and Electrostatic Air Cleaning

Another interesting application of static electricity is found in both large and small air purifiers. The electrostatic part of the process places an excess (usually positive) charge on smoke, dust, pollen, and other airborne particles, which then pass the air through an oppositely charged grid that attracts and holds the charged particles.
Smoke may look like a gas, but it's actually an aerosol. Most aerosols are made up of liquid droplets dispersed in a gas, but smoke is a little different: it's a solid dispersed in a gas. Smoke consists of microscopic particles of soot dispersed in hot, rising air

Imagine if you could "rub" all the tiny smoke particles as they enter the bottom of the smokestack (chimney) to give them a small charge... and wrap something like a sweater around the inside of the chimney at the top. n theory, charged particles of smoke would cling to sweaters, washing away dirt from the smoke and letting clean, warm air escape on its own. It sounds weird but here is the basic idea behind electrostatic smoke Precipitators.

Electrostatic smoke filters work by forcing dirty exhaust gas (gas escaping from the smokestack) through two electrodes, which are in the form of wires, rods, or metal plates inside the pipe or chimney. The first electrode is charged with a very high negative voltage. When dirt particles pass through, they pick up a negative charge. Further up the pipe, there is a second electrode made of metal plates that are charged with a high positive voltage (25,000 to 100,000 volts typically). Since unlike charges that attract each other, negatively charged soot particles are attracted to the positively charged plates and stick to them.

The collection plates must be shaken from time to time to clear the soot; this can be done manually (by someone cleaning them) or automatically (by some kind of automatic shaking or brushing mechanism in a process called rapping).



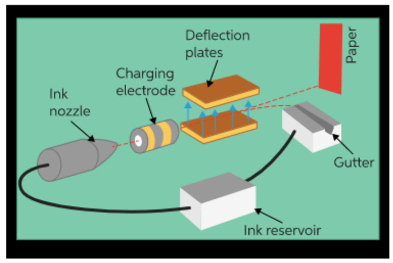
All electrostatic fume filters work essentially this way, with dirt particles receiving an electrical charge from one wire or plate before being drawn to a second wire or plate of opposite charge to collect and remove. There are variations though, with ESPs (electrical submersible pumps) designed to work in different ways based on different-sized dirt particles generated from different chemicals and different amounts of contamination.

Who invented it?
According to the Archives of the Research Corporation for Science Advancement, we get the basic idea of electrostatic precipitation from Dr. Frederick Cottrell (1877-1948), who performed the experiments first with this technology in 1906. In US Patent 895,729: The art of separating suspended particles from gases, filed in 1907, Cottrell described how to use high-voltage electrodes to make clean all kinds of smoke and dust from the factory.
Curiously, he also suggested that the same basic technology could be used for "the problem of destroying fog and mist outdoors, both on land and on water". That same year, he founded the International Precipitation Company to license his invention to other companies, including California's Western Precipitation. The first large-scale dust collector was a dust collector built by Western Precipitation for the Riverside Cement Company in 1911. Cottrell later worked with the British electrical pioneer, Dr. Oliver Lodge, and Dr. Erwin Moeller, German, to develop and commercialize this technology worldwide.

5. InkJet Printers and Electrostatic Painting

Inkjet printers commonly used to print computer-generated text and graphics, use static electricity. A nozzle makes a fine spray of tiny ink droplets, which then receive an electrostatic charge.

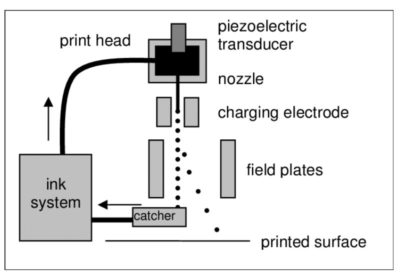
An inkjet printer is a printer that creates images by placing very small drops of ink on paper. The dots are small, about 50 to 60 microns in diameter, smaller than the diameter of a human hair (70 microns). The resolution is approximately 1440 x 720 dots per inch (dpi). It can have different colors combined to form a dot, producing high-quality images. Inkjet printers have a print head with 300 to 600 chambers that are tiny nozzles used to spray thousands of ink drops per second in a precise pattern to compose text and images on a page. There are two types of inkjet printing technology to squirt ink droplets, thermal bubble printing technology, and piezoelectric printing technology.



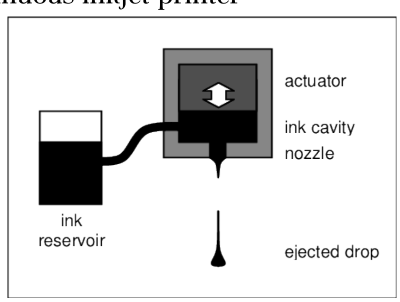
The principles of inkjet printing are divided into two main categories and minor categories. The main division is between continuous and drop-on-demand processes.

As the name suggests, the continuous inkjet process begins by forming ink droplets from a continuously flowing inkjet that is ejected from the nozzle under pressure. Disturbance at a particular wavelength along the jet will increase and eventually break the jet into droplets. By applying a regular disturbance at the correct frequency (with a piezoelectric transducer, for example) his breaking can be controlled and produces a very uniform droplet flow. Certain droplets from this stream are then individually selected for printing. A common method of choosing or selecting involves using conductive ink and inductively charging the droplet during its formation by placing an electrode nearby maintained at an appropriate potential. When the droplet separates from the flow, the induced charge cannot flow along the liquid column and is retained on the drop; the electrode can then be switched to a different voltage to charge the next droplet to be formed. The droplets then pass through a fixed electric field that deflects the charged droplets by an amount depending on their charge. Uncharged droplets are retained and the ink reused, while charged droplets are directed at the substrate and the level of charge controls where they collide with it. In this way, a single jet can print a line of characters by charging droplets of different levels to form a line, such as 7 or 15 high drops. Characters are created by moving the substrate and printing consecutive lines. In a more complex

system, four or more arrays of continuous jets, each printing a primary color and each jet addressing one row of pixels along the substrate, can be used to print color images very quickly.
It is typical to notice that as the ligament separates to create a stream of droplets in this manner, in addition to the main drop, smaller satellite drops are also frequently produced. Depending on the specifics of the applied disturbance and the properties of the ink, these satellite drops will either reunite with the primary drop or be redirected to undesirable regions and result in subpar printing and printer failure. There have been several attempts to intentionally produce small satellite drops for high-resolution printing.
"drop-on-demand" is the second important inkjet technology. A drop of ink is only ejected from each of the several nozzles on drop-on-demand print heads when it is necessary to create the desired picture. An actuator of some sort causes a quick change in the cavity volume and gives the ejected drop some momentum. This is a dynamic process, and the geometry of the cavity behind the nozzle and wave propagation in the ink both play a big role. The two most popular ways to cause the ejection, while alternative strategies have been investigated, are the formation of a vapor bubble inside the ink using a heater pad (a process known as "bubble jet") or the distortion of a piezoelectric ceramic element. The ink droplet is released as a jet first, then as a ligament or tail that is still attached to the ink in the nozzle.



(a) continuous inkjet printer



(b) drop-on-demand print head

In some ways, drop-on-demand technology is simpler than continuous since it does not need an external drop selection and recovery system, but the manufacturing processes for print heads, especially those with numerous small nozzles, which are quite difficult. Any drop-on-demand system must contend with the necessity for the ink to solidify or dry on the printed surface while avoiding drying inside the nozzle or clogging it. Using low-volatility inks and absorbing substrates, heaters, dryers, or UV-curable inks, as well as appropriate cleaning and capping, for example, can solve this at the print head and at the substrate, accordingly.

With electrostatic, you can perform a number of cool tricks. For instance, you can:-

- Levitating lightweight items,
- constructing an electroscope,
- controlling the balloons' movement,
- bending water,
- Making Styrofoam balls dance around in aluminum foil,
- controlling bubbles,
- moving a stick,
- rolling a can around without touching it,
- Hover a Styrofoam plate...etc

Summary

In general, since the Greek times, when rubbing hair or animal fur before touching dead grass (was regarded as remarkable), people have been aware of static electricity. However, it wasn't until 1775 that the force began to gain more visibility and comprehension. It was in that year that renowned Italian physicist Alessandra Volta developed and popularized a device he referred to as a "Perpetual electrophorus" that allowed electrical charges to be transferred from one object to another. A few years later, German physicist Georg Christoph Lichtenberg produced amazing visuals known as Lichtenberg figures using a massive electrophorus, or what we would today refer to as a manual capacitive generator. He had found a way to record images made by static electricity on paper, which gave rise to the fundamental principles of xerography and the physics behind copy machines.

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