International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue14
November 2017

Theory and Application of Electrostatics

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Abstract

Researches on electrostatics' conceptions found that students have ideas and conceptions that disagree with the scientific models and that might explain students' learning difficulties. To favour the change of student's ideas and conceptions, a teaching sequence that relies on a historical study of electrostatics is proposed. It begins with an exploration of electrostatics phenomena that students would do with everyday materials. About these phenomena they must draw their own explanations that will be shared and discussed in the class. The teacher will collect and summarize the ideas and explanations which are nearer the history of science.

Introduction

Vandegraaffgenerator

Basically, It is an electrostatic generator which is capable to generate high potential difference.

PRINCIPLE:- The whole working of van de graaff generator is based upon two of the following phenomena of electrostatics.

1. Discharge action of sharp points(corona discharge) .This electric discharge takes place in air

or gases readily at the pointed ends of conductors.corona discharge- The process by which the charge at the pointed conductor gets discharged is called corona discharge.

2. If a charged conductor is brought into internal contact with a hollow conductor all of its charge transfers to the hollow conductor howsoever, high the potential of the latter may be.

Constructions:-

A large conducting spherical shell above an insulating column . A long belt of insulating material is wounded over two pulleys and these of the two belt passes over two brass combs .The comb one which is given potential is called spray comb and the other one is collecting comb.

e-ISSN: 2348-6848
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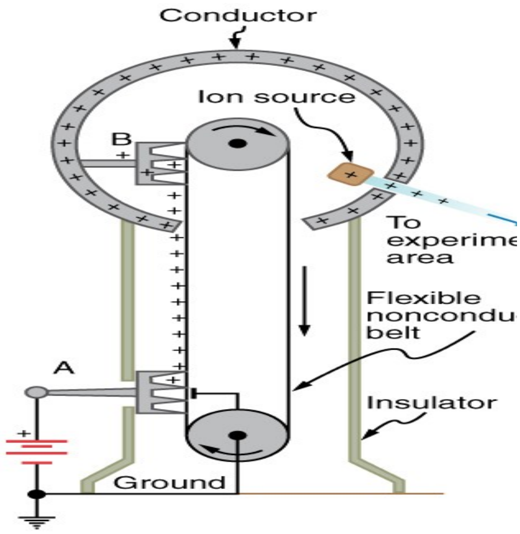
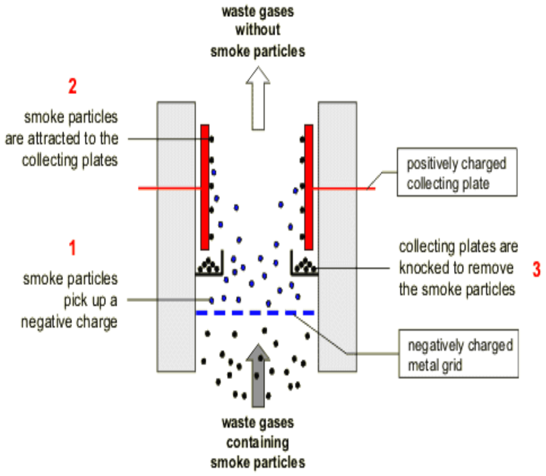
2. Electrostatic Dust Precipitators





WORKING:- Due to high electric field at the point ends of combthe air around it gets ionised and the positive or negative charge is repelled or sprayed over the belt which moves up to spherical shell. As it passes through collecting combs it induces negative charge at the ends and positive charge on the shell. The positive charge spread over the spherical shell. The high electric field generated at collecting comb ionises the air around it and reples the negative charge on the belt which neutralises its positive charge. A discharge tube is placed with its upper end inside the hollow sphere end earthed. The ion source is placed at the upper end of the tube . The high potential on the sphere reples the charged particles downward with large acceleration, where they hit the target atom to bring about the nuclear dis integration.

USES:- The high potential difference generated is used to accelerate charged particles like protons,deuterons etc. to high energies.

In big cities the factories work round the clock and the smoke coming out of the chimmneys contain a lot of unburnt carbon particles. Smoke is a colloidal solution of solid particles such as carbon arsenic compounds dust etc. in air .These are quite injurious to health have to be precipitated from the smoke.Infact,smoke is a colloidal system in which the carbon particles are suspended in air . the carbon particles are charged in nature and they do not get coagulated or precipitated.

The charge on the carbon particles is neutralised by bringing them in contact with the oppositely charged metal plate .they thus get precipitated and the smoke coming out of the chimney is free from dust. This precipitation of smoke particles is carried out by Cottrell smoke precipitator . In this method the smoke is allowed to pass through a chamber having a series of plates charged to very high potential. Charged particle of smoke gets attracted by charged plates get precipitated and the gases coming out of chimney become free of charged particles.

Cathode Ray Oscilloscope

e-ISSN: 2348-6848
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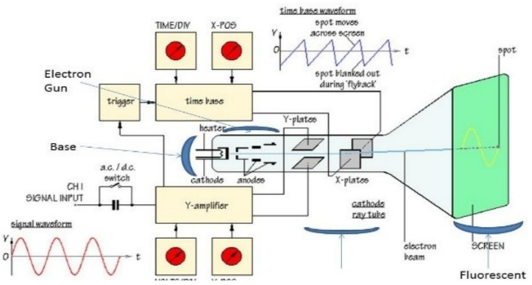

The cathode ray tube is a vacuum tube that contains one or more electron guns and a phosphorescent screen, and is used to display images. It modulates, accelerates, and deflects electron beam)onto the screen to create the images. The images may represent electrical wave, pictures (television, computer monitor), radar targets, or others. CRTs have also been used as memory devices, in which case the visible light emitted from the fluorescent material (if any) is not intended to have significant meaning to a visual observer.In television sets and computer monitors, the entire front area of the tube is scanned repetitively and systematically in a fixed pattern called a raster. An image is produced by controlling the intensity of each of the three electron beams, one for each additive primary color (red, green, and blue) with a video signal as a reference. In all modern CRT monitors and televisions, the beams are bent by magnetic deflection, a varying magnetic field generated by coils and driven by electronic circuits around the neck of the tube, although electrostatic deflection is commonly used in oscilloscopes, a type of electronic test instrument.

Photocopy

Electrostatics is used in photocopying machine and laser printers which almost possesses same functions. The basic principle behind this is the fundamental laws of Electrostatics that the attraction forces act between oppositely charged particles.

Electrostatic Loudspeaker

An electrostatic loudspeaker (ESL) is a loudspeaker design in which sound is generated by the force exerted on a membrane suspended in an electrostatic field.The speakers use a thin flat diaphragm usually consisting of a plastic sheet coated with a conductive material such as graphite sandwiched between two electrically conductive grids, with a small air gap between the diaphragm and grids. For low distortion operation, the diaphragm must operate with a constant charge on its surface, rather than with a constant voltage . This is accomplished by either or both of two techniques: the diaphragm's conductive coating is chosen and applied in a manner to give it a very high surface resistivity, and/or a large value resistor is placed in series between the EHT (Extra High Tension or Voltage) power supply and the diaphragm *(resistor not shown in the diagram here). However, the latter technique will still allow distortion as the charge will migrate across the diaphragm to the point closest to the "grid" or electrode thereby increasing the force moving the diaphragm, this will occur at audio frequency so the diaphragm requires a high resistance to slow the movement of charge for a practical speaker.The diaphragm is usually made from a polyester film with exceptional mechanical properties, such as PET film. By means of the conductive coating and an external high voltage supply the diaphragm is held at a DC potential of several kilovolts with respect to the grids. The grids are driven by the audio signal; front and rear grid are driven in antiphase. As a result a uniform electrostatic field proportional to the audio signal is produced between both grids. This causes a force to be exerted on the charged diaphragm, and its resulting movement drives the air on either sideofit.The grids must be able to generate as uniform an electric field as possible, while still allowing for sound to pass through. Suitable grid constructions are therefore perforated metal sheets, a frame with tensioned wire, wire rods, etc.*

To generate a sufficient field strength, the audio signal on the grids must be of high voltage. The electrostatic construction is in effect a capacitor, and current is only needed to charge the capacitance created by the diaphragm and the stator plates . This type of speaker is therefore a high-impedance device.

Advantages

Advantages of electrostatic loudspeakers include levels of distortion one to two orders of magnitude lower than conventional cone drivers in a box, the extremely light weight of the diaphragm which is driven across its whole surface, and exemplary frequency response (both in amplitude and phase) because the principle of generating force and pressure is almost free from resonances unlike the more common electrodynamic driver. Musical transparency can be better than in electrodynamic speakers because the radiating surface has much less mass than most other drivers and is therefore far less capable of storing energy to be released later. The concomitant air load, often insignificant in dynamic speakers, is usually tens of grams because of the large coupling surface, this contributing to damping of resonance buildup by the air itself to a significant, though not complete, degree. Electrostatics can also be executed as full-range designs, lacking the usual crossover filters and enclosures that could colour or distort the sound.Since many electrostatic speakers are tall and thin designs without an enclosure, they act as a vertical dipole line source. This makes for rather different acoustic behavior in rooms compared to conventional electrodynamic loudspeakers. Generally speaking, a large-panel dipole radiator is more demanding of a proper physical placement within a room when compared to a conventional box speaker, but, once there, it is less likely to excite bad-sounding room resonances, and its direct-to-reflected sound ratio is higher by some 4–5 decibels. This in turn leads to more accurate stereo reproduction of recordings that contain proper stereo information and venue ambience. Planar drivers tend to be very directional giving them good imaging qualities, on the condition that they have been carefully placed relative to the listener and the sound-reflecting surfaces in the *room. Curved panels have been built, making the placement requirements a bit less stringent, but sacrificing imaging precision somewhat.*

Disadvantages

Typical disadvantages include sensitivity to ambient humidity levels and a lack of bass response, due to phase cancellation from a lack of enclosure,[citation needed] but these are not shared by all designs. The bass roll off 3db point occurs when the narrowest panel dimension equals a quarter wavelength of the radiated frequency for dipole radiators, so for a Quad ESL-63, which is 0.66 meters wide, this occurs at around 129 Hz, comparable to many box speakers There is also the difficult physical challenge of reproducing low frequencies with a vibrating taut film with little excursion amplitude; however, as most diaphragms have a very large surface area compared to cone drivers, only small amplitude excursions are required to put relatively large amounts of energy out. While bass is lacking quantitatively it can be of better quality than that of electrodynamic systems.

Conclusions

These observations can help students to understand the lightning and to change their conception about the nature of electrostatics and of electricity of current, which is the same. With the Van der Graff it is possible to produce sparks very far from the generator, and so students can relate the electricity by friction and the electricity of current. To conclude we can say that with this type of teaching proposal, students will learn conceptual aspects of electrostatics as well about experiments' interpretation, but also they will learn about the nature and history of science and culture, as well as about argumentation.

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