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WIMSHURST MACHINE: A PROJECT APPLIED TO TEACH PHYSICS

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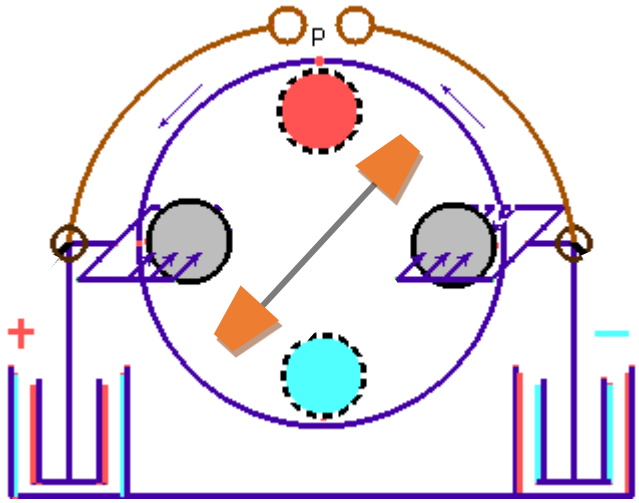
Graphical Abstract



Abstract.

The figure on the side is a simplified representation of the operation of the Wimshurst machine. Two insulating discs rotate in opposite directions, where two or more conductive plates are attached symmetrically on their outer surfaces. The two dashed plates are on the back disk, the other two on the front disk. Once obtained by friction, these charges are accumulated in Lyden bottles, and when there is a sufficient potential difference between the terminals of the two Lyden bottles, dielectric rupture occurs, and the electric discharge is visualized when ionizing the air.

Introduction

The Wimshurst machine is an electrostatic generator of high voltage and low current, which was developed between 1880 and 1883 by British engineer James Wimshurst. This apparatus can accumulate electrical charges through the process of friction and the electrostatic induction present between two disks that rotate in opposite directions, which also allows the separation of these electric charges. Once obtained by friction, these charges are accumulated in Leyden bottles, and when there is an enough potential difference between the terminals of the two Leyden bottles, dielectric rupture occurs,

and the electric discharge is visualized when ionizing the air. The purpose of using the Wimshurst machine in teaching situations is to introduce and demonstrate fundamental concepts of physics. In our didactic experience, we highlight the approach with the students and the public in extension activity, of the most diverse concepts of Electrostatics like: Electrostatic Induction, Potential Difference, Electric Field, Capacitors, Electric Discharge, Dielectric, and Dielectric Breakdown.

Materials and Methods

The construction of the Wimshurst machine was based on a video [1] and we used the following materials for its construction: two 30 cm acrylic discs, two Leyden bottles, aluminum plates, wood, iron, straps, pulleys, crank, screws, glue and copper wires. Initially we made a base with wood, mounted the acrylic disks with the metallic sectors, made the Leyden bottles as well as the load collectors and the neutralizers. With these parts ready, we went to a workshop to join these pieces, which brought the first prototype of the machine, as shown in figure 1.

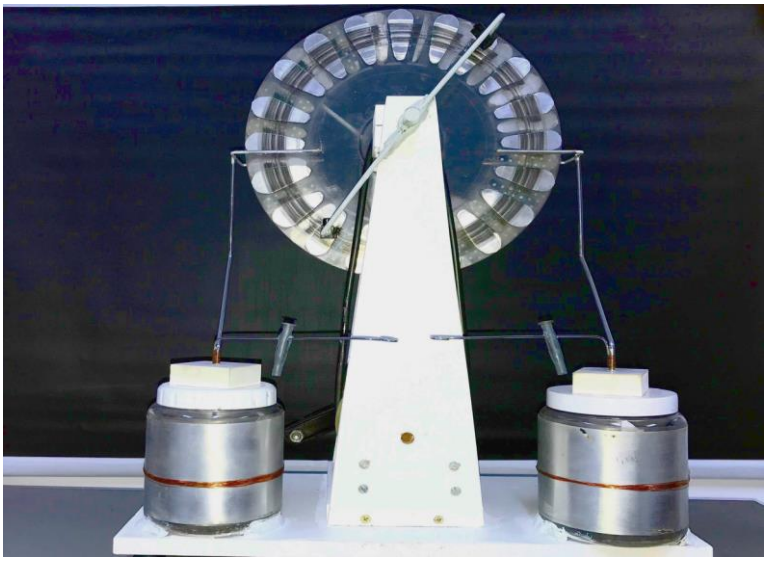


Figure 1: Illustrative image of the Winshurst machine

Results and Discussion

After the construction of the machine we started the test phase to verify its real operation and we realized that this was not one of the best, with that we made a new assembly of the machine in which we changed the straps and we approached the acrylic discs, thus presenting the first signs of induced loads. We realized that even with this modification the machine had no capacity to accumulate these

electric charges, thus presenting an unsatisfactory efficiency. We corrected the error of the Lyden bottles and got the final version of the machine.

The two disks present in the machine are made of insulating materials that rotate in opposite directions, in these disks were fixed several metallic sectors allowing the generation of electric charges. The machine needs an initial charge to start its operation usually this charge is a residual charge that exists on the disks themselves. In front of each disk there is a metal bar that receives the name of neutralizing bar at its ends there are metallic wires that touch the sectors of the machine while the discs rotate, this configuration allows the production of electric charges. The separation of the electric charges is carried out by electrostatic induction which occurs when a metallic sector passes through a brush and an influence occurs by the opposite disk generating two regions being Zone 1 the positive charges and Zone 2 the negative charges. On the sides of the discs there are two "U" shaped parts (C1 and C2) called charge collectors collecting the charges of the C1 positive charges and C2 negative charges. These collectors are connected to the Leyden bottles until the voltage between the terminals reaches a value sufficient to break the dielectric barrier of the air producing sparks as shown in Fig.2 [2]

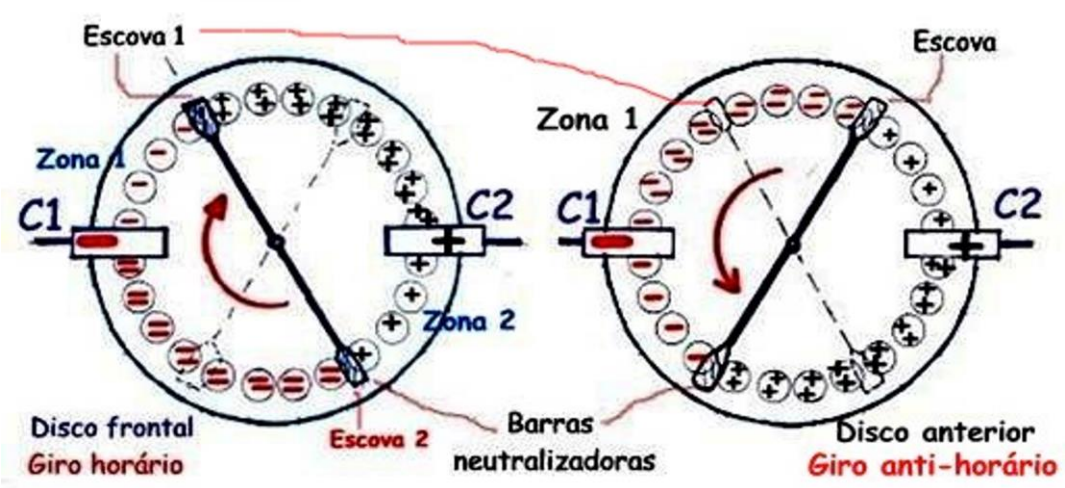


Figure 2: Illustrative image of the production and separation of electric charges by electrostatic induction process. [2]

The Wimshurst machine was used in demonstrations of physics classes during the institutional program (Pibid), we realized that in the classes of electricity given in the third years we use an experimental artifact as a teaching resource and explain the concepts of electrostatics through the operation of the machine, we can observe that the learning and fixation of the contents was better perceived by the students and us teachers than if these contents were taught by the traditional method or expository classes. Because it is a visually appealing and motivating phenomenon from the point of view of students' particular curiosity and interests due to phenomena of this type, popularly known as

lightning, we associate the construction, use and study of this apparatus as important characteristics and of great potential for teaching of Physics. This device can cause an electric shock of thousands of volts (but with a current of the order of microamperes) in dozens of people at the same time, which takes the public to a particular interest by the device. During the PIBID classes, we finished the presentation of the machine, showing the capacity of the machine to produce electrostatic energy, giving the students that interested, to be able to feel this energy when leaning on the machine.

Conclusions

Given the above, we can conclude that the Wimshurst machine obtained a satisfactory result in the application to the physics teaching, when it was used as an experimental artifact, it enabled the explanation and demonstration of phenomena of static electricity, becoming a very useful teaching resource to be applied to high school students, who showed great interest in the class due to the existence of the Wimshurst Machine.

References

[1] Disponível em: https://www.youtube.com/watch?v=a0BiD9MjUZA, Acesso em: 17-out -2018

[2] Disponivel em: https://www.ifi.unicamp.br/~lunazzi/F530_ F590_F690_F809_F895/F809/F609_ 2013_sem1/Alexandr eD-Mauro_RF2.pdf, Acesso em 18-out-2018