The Wimshurst Machine

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Objective:

The objective of this project was to build a working Wimshurst Machine, an influence machine which uses induction to create charge.

Introduction:

The Wimshurst machine was created between 1880 and 1883 by James Wimshurst (Dibner, Pg 47). This machine was the culmination of hundreds of years of experimentation with primitive electrical generators. The first electrical generator was created by Otto von Guericke in 1660 (Pg. 14). Guericke's generator was very simple, and consisted of a sulfur ball attached to a metal rod. Guericke would spin the rod, which in turn would rotate the ball. A "dry hand" was then rubbed against this rotating sphere, and a charge would accumulate on the sulfur ball. Guericke noted this charged balls ability to "attract paper, feathers, lint and other lighter objects" (Pg. 14). This electrical generator was a friction machine, because it used friction to create charge. Friction machines continued to evolve throughout the 18th and 19th centuries. The performance of these electrostatic generators was greatly enhanced with the invention of the Leyden jar in the 1740's (Pg. 25). Invented by Pieter van Musschenbroek in Leyden, a small town in the Netherlands, the Leyden jar was capable of storing the charge produced by an electrostatic generator. Electrostatic devices were based solely on the principles of friction until 1831, when Michael Faraday discovered electromagnetic induction (Jenkins). Faraday's concept of induction would provide the basis for a new class of electrostatic generators, which would now operate on the principles of induction rather than friction. The Wimshurst machine would eventually use induction to astonishing effect, and it would become the most recognized type of influence machine. From its invention in the 1880's until the creation of the Van de Graaf generator in 1929, "the Wimshurst machine was the most common mechanical device used to produce extremely high potentials" (Weisstein).

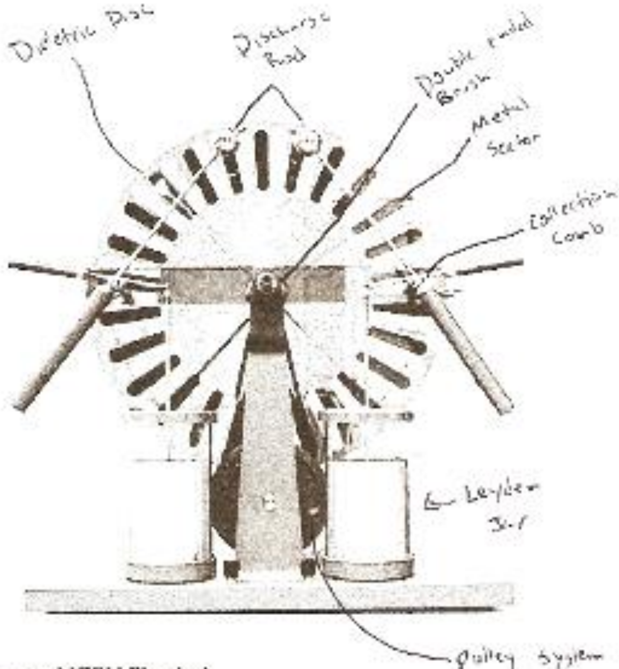
Construction:

The Wimshurst machine consists of two discs that are made of some dielectric, most commonly glass. Metal sectors are spaced evenly along the outer edge of these discs, and the discs are then mounted to a hand operated drive system. The drive system in configured so that when the crank is operated, the discs rotate in opposite directions of each other. Double ended brushes are then arranged perpendicular to each other on the outer edge of both plates. Between the brushes is placed a collection comb, which is also connected to a Leyden jar and a discharge rod. This project used Plexiglas for the discs and aluminum tape for the metal sectors. The double ended brushes were constructed out of thick copper wire for the rod, and alligator clips with thin copper wire for the brush. This project did not have collection combs in the usual sense, rather it used thin copper wire which was directly connected the Leyden jar. Discharge rods were then constructed out of thin copper wire which was balled at one end, and also inserted into the Leyden jar. The base for the machine was made of wood, as was the support beams which held the discs. The crankshaft was constructed out of a PVC rod and a fishing reel handle. Finally, the pulley system was built out of plastic pulleys and rubber bands.

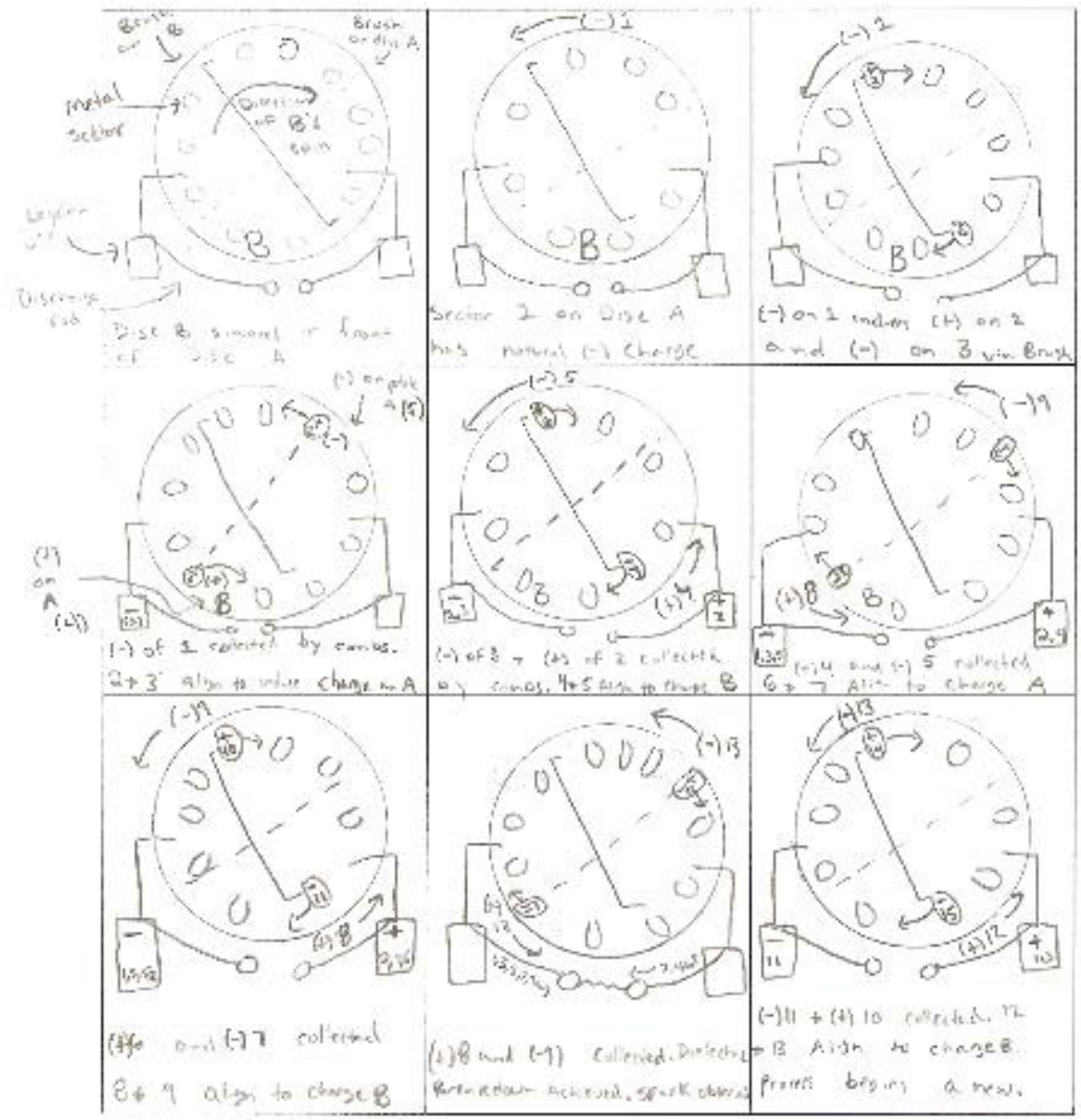
Theory:

The electricity generated by the Wimshurst machine is created solely by the principles of induction. Pretend that one of the metal sectors, sector 1, on one of the plates, plate A, contains a natural negative charge. As this negatively charged sector spins, it eventually lines up with the brush positioned on the opposite disc, disc B. The negative charge on the sector 1 induces a charge separation on a sector on disc B, sector 2, which is also aligned with the brush. Charge separation occurs because the natural positive charges on sector 2 are attracted to the natural negative charge on sector 1. The positive charge induced on sector 2 is held in place by the attractive force between it and the negative charge on sector 1. However, the negative charge induced on sector 2 seeks to get as far away as possible from the negative charge on sector 1, since like charges repel. Sector 2 is then grounded by the brush, which picks up the negative charge on the sector and deposits it on a sector that is on the exact opposite position on plate B, sector 3. Sectors 2 and 3 have now been charged by induction. Plate B continues to spin with two oppositely charged sectors, until these sectors align with the brush situated on Plate A. Two sectors on Plate A are now charged by induction so that Plate A also contains two oppositely charged sectors located at exact opposite ends of the disc. As the two discs spin, the charges on the sectors will be collected by two collection combs. One of the collection combs will collect the positive charges, while the other will collect the negative charges. This process will continue until the Leyden jars contains enough charge that the air between the discharge rods reaches the dielectric breakdown point, and a spark is observed between the spark gap of the discharge rods (MIT).

<u>Diagrams:</u>



(Source: NCSU Physics)



Metal sector
Direction of B's spin
Sector 1 on Disc A has natural (-) charge
(-) on 1 induces (+) on 2 and (-) on 3 via Brush
(-) of 1 collected by combs.
(-) of 3 + (+) of 2 collected by combs. 4+5 Align to charge B
(+) 4 and (-) 5 collected
6 + 7 Align to charge A
and (-) 7 collected
8 + 9 align to charge B
(+) 8 and (-) 9 collected. Dielectric
breakdown achieved. spark observed
(-) 11 + (+) 10 collected. 12 + 13 Align to charge B
Process begins a new.

Conclusion:

The final result of this project was the successful creation of a working Wimshurst machine.

Using induction, this machine is capable of producing up to a 1.5 cm spark.

Works Cited

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