Tesla Coil
Team Project 1
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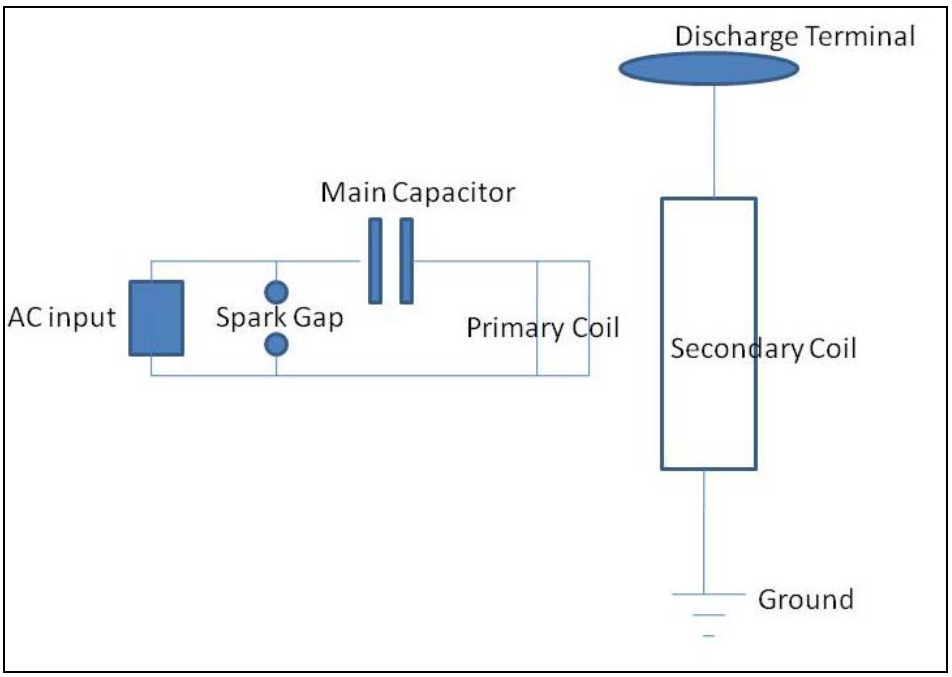
Image Intent:

The purpose of this image is to visualize a plasma flow created by a corona discharge, using the electrodes created with a Tesla coil. Tesla coils were originally created by Nikola Tesla, as a means of experimenting on the possible transmission of electrical power over long distances without the use of transmission wires. Although these experiments were never successful in achieving this goal, the fluid flows created by this device are beautiful and also display very interesting phenomena, since plasma flows are probably the least observed fluid flows in daily life (excluding the sun, which is plasma). This particular image shows a long electrical arc between the two electrodes of the Tesla coil, as opposed to other images which show the coil discharging into the surrounding air.

Flow Apparatus:

Tesla coils work, in the simplest way, by creating a very high voltage difference between two different diodes. The potential difference between the diodes is high enough that the molecules in the surrounding air are dissociated, allowing the electric current to flow through the dissociated electrons. Tesla coils create such a large potential difference through the use of capacitors and magnetic induction. First a tank capacitor is charged to a point that it can jump a small gap, known as the main spark gap. At this point the primary LC circuit begins to oscillate, inducing a current in the secondary LC circuit. The secondary current also oscillates but is constrained to this circuit. As the tank capacitor is charged over and over again, the potential that is stored in the second LC circuit continues to increase until it reaches a point that it can arc from that diode to a grounded diode. The value of the output voltage can be discovered using this equation Vout = Vgap*SQRT(X*Cp/(Cs+Ct)), where the Vgap is the voltage passed through the spark gap, the Vout the output voltage, X is the transfer rate from the primary LC circuit to the Secondary LC circuit. Cp is the primary capacitance and Cs is the capacitance in the secondary LC circuit.[i] Unfortunately this information is not available for the Tesla coil used in creating this image. Even so this image can be recreated with many different coils, the field of view is the only thing that would be affected because the distance of the arc is dependant on the output voltage of the system. An estimate is 50,000 Volts.

Figure One: Circuit Diagram



Visualization Technique:

The image taken actually shows many different fluid flows, because of the relatively long shutter speed used on the camera. Each individual line, in fact, represents a single fluid flow. No seeding was necessary. The image shows that where the current is arcing through the air between the two diodes, the air molecules are actually being ionized. This occurs because of the very large potentials of the diodes is enough to raise the energy levels of the electrons in the air molecules to an energy level high enough that they dissociate from the individual molecules. This allows a current to flow between the two diodes, in turn, lowering the potential of the diodes. As the potential decreases the molecules return to lower energy states and release photons of light, that give the flow streams their color.[ii]

Photographic Technique:

This image was taken with a digital camera, the canon EOS 50D. The lens used was a EF-S 18-200mm f/3.5-5.6 IS Standard Zoom Lens. The shutter speed on the camera was set to 1.0 sec. in order to allow many flow streams to enter the image, and increase the brightness of the flows. The F-Stop on

the camera was manually set to f/5.6. Aperture was also manually to a value of f/5.7. The ISO Speed rating was 100. The focal length of the lens was 100mm. There was no flash. Because the image created light itself, it was seen best with the lowest light possible. For this reason the image was taken in a dark room with only very small amounts of ambient light. Originally the image was 4752 pixels in the horizontal direction and 3168 pixels in the vertical direction. Using Adobe Photoshop, the pixel dimensions were reduced to 2284 and 1312 in the horizontal and vertical axis, respectively. Photoshop was also used in order to brighten the lines of the image. This was done using the curves function to very slightly darken the dark areas and brighten the rest. This method was very effective because the flow is very bright, while the rest of the environment is very dark. The field of view in the final image is about 2 feet wide and about 1'2" high. The original field of view is 4'2" high and 2'9" wide. The camera was pointed nearly parallel to horizontal a distance of 15' away from the Tesla coil.

Future Work:

In many ways this image does fulfill its purpose. The image shows the plasma flow very well and is also aesthetically pleasing. During research on Tesla coils, I also discovered images of Tesla coils creating much larger flows than the one used for this image. I think that it would be very interesting to see how long of a flow could be created using larger coils, although it would most likely be difficult to acquire the apparatus necessary for this. The image was also substantially cropped. This should have been avoided, especially since a more zoom was available on the camera. Fortunately the camera used was a large megapixel camera so the cropping didn't result in an overly pixilated image.

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[i] "A High Potential Tesla Coil Impulse Generator for Lecture Demonstrations and Science Exhibitions. American Journal of Physics -- August 1997 -- Volume 65, Issue 8, pp. 744-754 Issue Date: August 1997

ii "A High Potential Tesla Coil Impulse Generator for Lecture Demonstrations and Science Exhibitions. American Journal of Physics -- August 1997 -- Volume 65, Issue 8, pp. 744-754 Issue Date: August 1997