Tesla Coil: Shock and Awe

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In 1891 (Bellis), Nikola Tesla invented an apparatus that he wanted to use to wirelessly power other electronic devices. Despite the fact that this apparatus was never able to wirelessly transmit electricity in an efficient manner, it is still an enjoyable project for aspiring physicists to construct. This device was named the Tesla Coil after its creator.

The Oxford Dictionary of Science defines the Tesla Coil as, "a device for producing high-frequency high-voltage current. It consists of a transformer with a high turns ratio, the primary circuit of which includes a spark gap and a fixed capacitor; the secondary circuit is tuned by means of a variable capacitor to resonate with the primary." Although some scientists use expensive kits, it is possible to build a functioning Tesla Coil using household items, a commercial transformer, and the design found on instructables.com (DevCoder).

The first step in building a Tesla Coil was making the capacitors. The capacitors were built by wrapping six 16 oz. Snapple® bottles with aluminum foil and aluminum tape. Then, the bottles were filled with a salt water and mineral oil solution, composed of two teaspoons of table salt and one half a teaspoon of mineral oil per bottle. After the bottles were filled to the neck and wrapped properly, as shown below, they were wired in parallel in order to maximize the total capacitance of the system (a little less than 3 nF).

Figure 1 – Capacitors

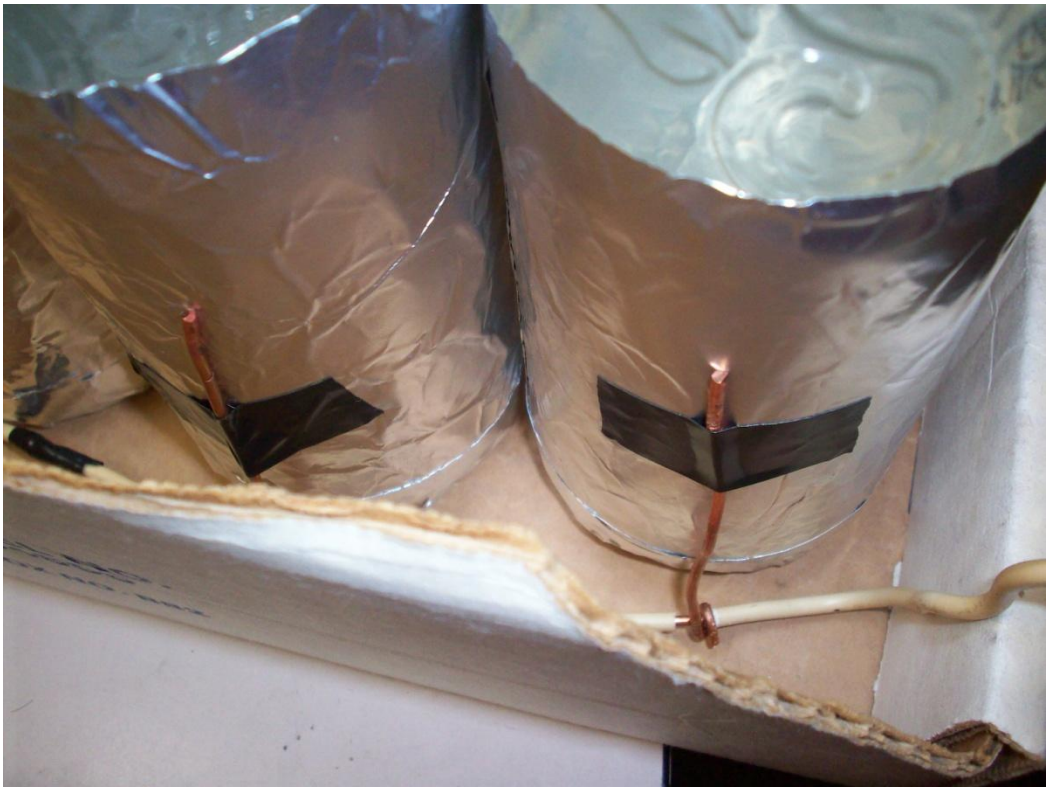

Figure 2 – Wiring the Capacitors

The next step was constructing the base of the coil. For the base, two 2.25 sq. foot plywood boards were used. The bottom base contained the transformer, the capacitors, and the spark gap. The spark gap consisted of two L-brackets attached to the board. Two 1-inch machine screws were attached to the brackets and screwed in until they were not quite touching, as shown in the figure below. Then, the transformer was screwed into the bottom base behind the spark gap.

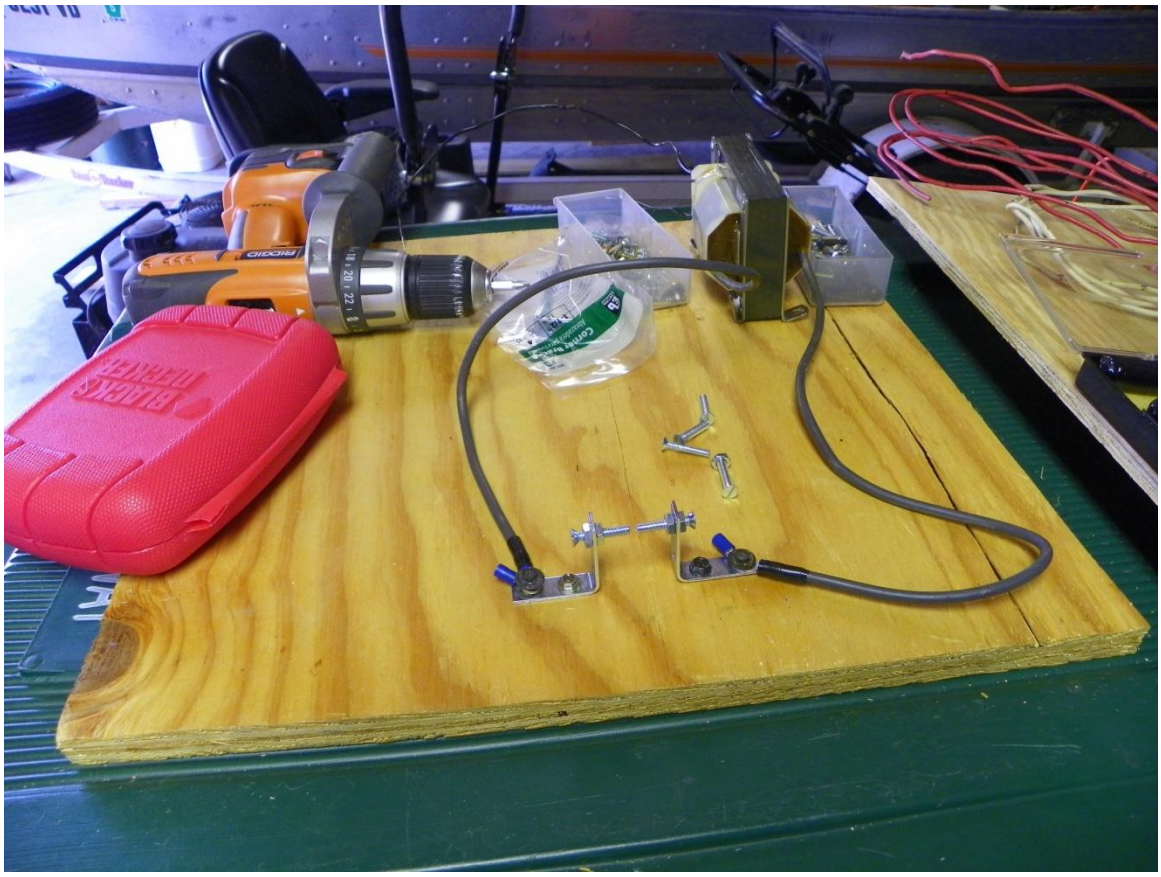

Figure 3 – Spark Gap and Transformer

The top base was attached to the bottom base using four 8.5” long 9/8” diameter dowel rods. The top base contained the primary coil, the primary coil’s supports, and the secondary coil. The secondary coil was constructed by wrapping 24-gauge magnet wire around a 1.5” diameter PVC pipe approximately six hundred times, and then spraying it with three coats of enamel. A circular hole was cut out of the top base and a 1.5” PVC screw was placed in it. Then, the

secondary coil was attached to the top base by inserting it into the PVC screw. Next, the primary coil was constructed by winding 10 feet of ¼" diameter copper tubing around the secondary coil seven times, as shown in Figure 5. Then, three 9/8" diameter dowel rods were screwed into the top base as a support for the primary coil. The primary coil was attached to its supports using plastic zip ties. Finally, a smooth, circular toroid was wired to the top of the secondary coil. The total cost of building a Tesla Coil using this design was approximately $175

Figure 4 – Secondary Coil

Figure 5 – Primary and Secondary Coil

The last step in building the Tesla Coil was to wire each component together as shown in the circuit below. First, the transformer was attached to a power cord. Then, the output of the transformer was attached to one side of the spark gap. Next, that side of the spark gap was wired to the negative side of the capacitors. The positive side of the capacitors was then wired to the bottom end of the primary coil. A wire was attached to the top of the primary coil via an alligator clip, and this wire ran back to the other side of the spark gap, which was attached to the transformer's second output. The power cord was plugged into a foot switch, and the foot switch was plugged into a wall socket to allow for safe operation.

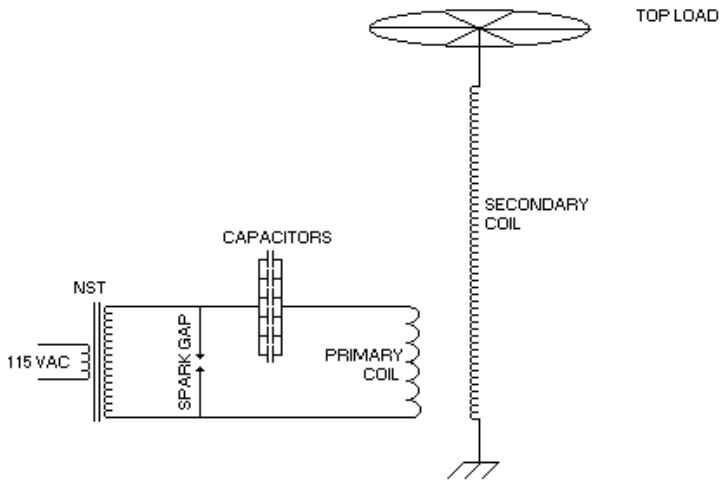

Figure 6 – Circuit Diagram (instructables.com)

When the power was turned on, the transformer changed the 120V of alternating current from the wall socket to about 6000V of direct current. This 6000V traveled through the circuit and charged up the capacitors until enough charge had been built up to cross the spark gap. Once it crossed the spark gap, the current traveled across the primary coil. The current flowing through the primary coil created a magnetic field around the coil, which created a magnetic flux inside the secondary coil. The changing magnetic flux induced a current and an emf in the secondary coil, according to Faraday's and Lenz's Laws. The induced current sought a ground, which caused the toroid to emit sparks.

The first time the Tesla Coil ran, the spark gap fired as planned, but no sparks were emitted from the doorknob toroid due to its small surface area. A decision was made to construct a larger toroid. The second toroid that was constructed was made from one 6" Styrofoam sphere wrapped in two layers of aluminum. The surface was not smooth enough, however, and a significant amount of electric charge was lost to the surrounding air. Finally, a toroid was borrowed from another Tesla Coil, and this toroid worked well enough to emit sparks.

The first time the bottles were constructed for the capacitors, only the sides were wrapped in foil. Also, the aluminum foil covered more of the outside of the bottles than the salt water solution covered on the inside. This resulted in sparking between the solution and the aluminum foil. In order to correct this, the bottles were rewrapped to make sure one could see the solution above the aluminum foil and also to make sure the bottoms of the bottles were wrapped in foil. This fixed the stray sparking issue.

In order to obtain maximum sparking, the spark gap and primary coil were tuned. Tuning the spark gap was accomplished by adjusting the machine screws in the spark gap to widen or shorten the gap between them. To tune the primary and secondary coils, the alligator clip on the primary coil was moved to change the length of the coil. The Tesla Coil needed to be tuned so that the primary and secondary coils would resonate at the same frequency, allowing for optimal output. After tuning it, the sparks emitted were approximately one centimeter in length.

Although the Tesla Coil did not perform as well as originally hoped, a great deal was learned about the nature of electricity and the principles behind the design and function of the Tesla Coil. This project proved that it is possible to construct a working Tesla Coil using household items and a commercial transformer.

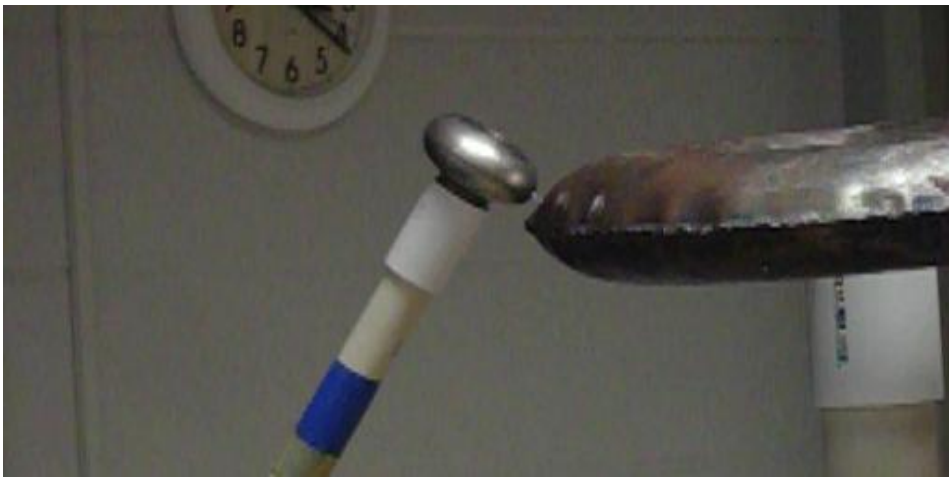

Figure 7 - Sparking

Works Cited

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