AA Battery Powered "Tesla Coil"

by **JoeBeau** on July 4, 2011

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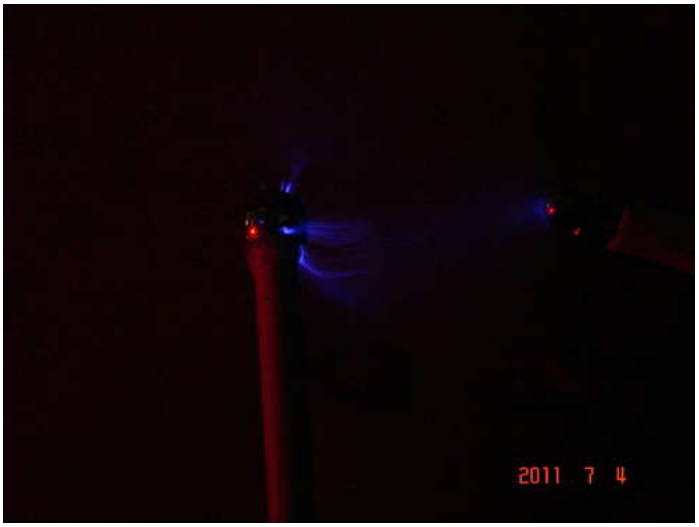
Intro: AA Battery Powered "Tesla Coil"

First things first:

DISCLAIMER: I am not responsible for any injuries or property damage that may befall you from following this instructable. High voltage electricity can be DANGEROUS and should only be worked with at your own risk. Proper safety precautions should always be followed.

That out of the way, welcome to my first instructable. Seeing as this is my first, any suggestions for improvements are greatly appreciated. Just go easy on me.
This is intended to be a how-to guide for a newbie to high voltage (like myself) looking for a quick, cheap, and relatively safe project. Although this is not a true tesla coil, as it does not utilize a resonant air-core transformer or operate at high frequencies, in effect it is similar. It still throws out plasma discharges from the top load and about 3.5 centimeter arcs to ground. Estimated output is about 100kv.



Step 1: Parts and Pieces

There aren't many parts to this build, and most can easily by scrounged from old TVs and other electronics or be bought for cheap. The following is needed:

Bug zapper racquet: This can be purchased from Ocean State Job Lot for about 5 bucks, and is nifty for fending of mosquitos or high voltage experiments. There are probably other types of devices very similar, but I would recommend finding the racquet pictured to insure the internal circuitry is the same.
Flyback transformer: Any flyback transformer will do, though the bigger the better. Don't kill yourself looking for an old non-rectified design, since there are no benefits of it for this circuit.
Random assorted hardware: This circuit requires a spark gap to be constructed. The design of the spark gap can vary, as long as the two ends where the arc jumps is rounded, and the gap adjustable. For mine, two Erector set brackets were used. One had a ball bearing soldered to it, the other a nut over top the hole, so a bolt with an acorn nut on the end can be threaded through. See the attached picture for the details.
2xAA battery holder: Can be purchased from Radioshack or the bug zapper handle can be used to hold the batteries.

Optional:
Additional Capacitors: Should be rated for at least 1.6 KV. The Bug zapper already contains one, but for bigger sparks more can be used.
Toggle Switch: The switch on the board of the bug zapper can be difficult to use, and because of the design of the bug zapper circuit, floats at high voltage, leading to a shock hazard when it is exposed. Because of this, a new switch is recommended.
Pen body or other plastic tube: To elevate the top load
Top load: I used a ball bearing, but anything smooth and without sharp edges or points can be substituted.

Of course, solder and a soldering iron as well as other general tools are needed, and wire for connecting everything together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Superhigh Voltage Bug Zapper
2011 7 4


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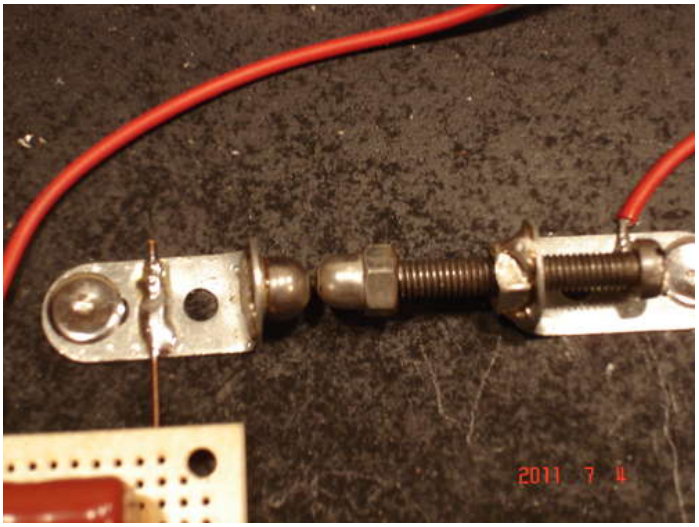
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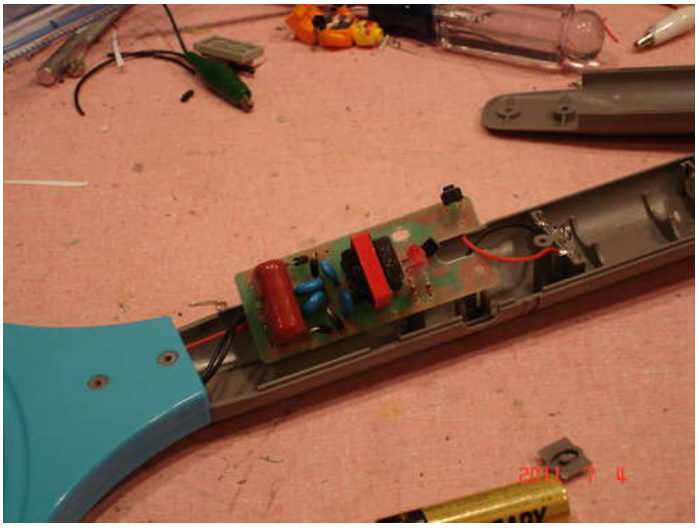
Step 2: Dismantle the Zapper

The bug zapper is easy enough to open. First, pry off the battery cover, and then remove the screws. There are two up near the head of the racquet, two near the bottom of the battery compartment, and another at the top of the battery compartment. Once removed, the back half of the handle can be lifted off, exposing the back of the circuit board. Remove the screw in the middle of the circuit board, and snip the wires running to the head of the racquet as close to the head of the racquet as possible, and snip the wires where they attach to the battery contacts. Now that the board is removed, the rest of the racquet is not needed.

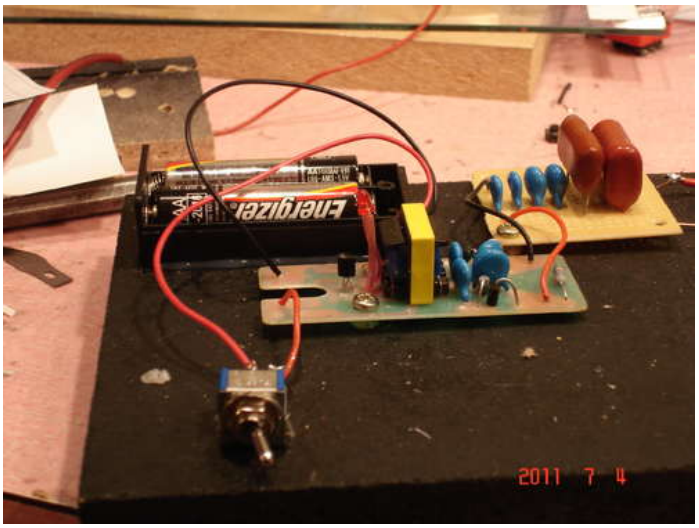
Image Notes
1. and here
2. Snip wires here...



Step 3: Prepare the Zapper Circuit

Now that the circuit is removed, it has to be slightly modified for our needs. First, remove the original momentary push switch, and in its place solder a jumper. Next, remove the negative battery wire from the board, and solder in its place the lead from the AA battery holder. Solder the positive battery wire on the board to the normally open lead on the toggle switch, and the positive lead from the battery holder to the common lead on the toggle switch. If you have extra capacitors, these can be used to make a capacitor bank. if you go this route, desolder the capacitor from the board, and set aside with the other capacitors. If you choose to not do this, leave the capacitor in its place. One of the black wires from the board's output can also be removed, since it is not needed. If you choose to make a capacitor bank, see below. Otherwise, the board is all set. The final product with capacitor bank is showed below, mounted on a piece of painted mdf.

Capacitor Bank:
This is relatively simple to make. Find as many high voltage capacitors as you want to use and wire them in parallel. In my case, I chose to use six, for no apparent reason. They can be mounted on a perf board as shown for a neater appearance.



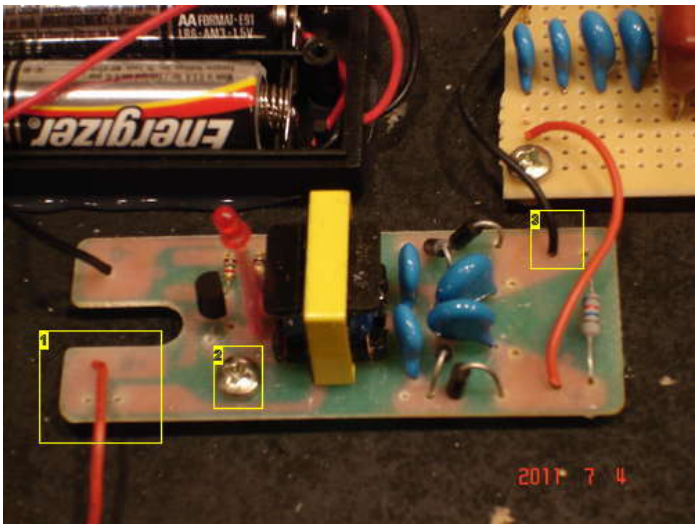


Image Notes
1. Switch removed. Jumper is on underside of board
2. Screw used to mount zapper board on wood
3. Second black wire removed

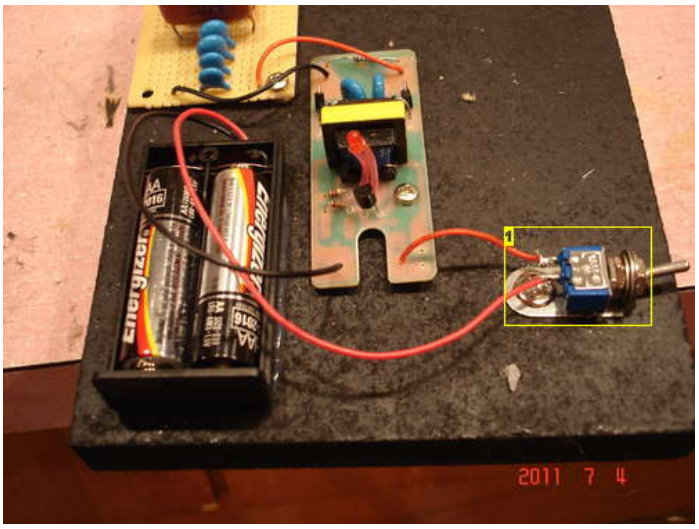


Image Notes
1. Angled bracket made from an erector set piece used to mount switch

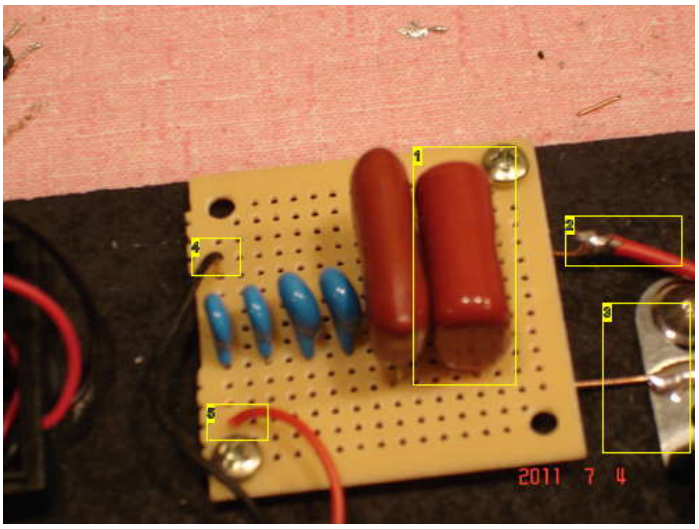


Image Notes
1. Capacitor from zapper
2. To flyback
3. To spark gap
4. From output of zapper board
5. Other output from zapper board

Step 4: Spark Gap

One of the wires from the zapper capcitor/capacitor bank feeds directly to the flyback transformer, which will be addressed in the next step, the other through the spark gap. The spark gap works to allow the capacitors to charge to the point when the electricity jumps the gap, and continues into the flyback. This creates short, powerful pulses to feed the flyback. The design of the spark gap can vary, but there are some general requirements:
It has to be adjustable for the width of the gap.
The ends of each electrode should be rounded.
The rounded shape is to prevent corona leakage between the electrodes. For my spark gap, one electrode is a ball bearing, the other a bolt with an acorn nut on the end. The electrodes are then mounted on Erector set pieces, and each nailed to the mdf that my whole setup is mounted on. the bolt can be screwed in or out to adjust the width of the gap. The wider the gap, the slower but more powerful the pulses, the narrower the gap, the faster but weaker the pulses. The gap then feeds into the flyback transformer.

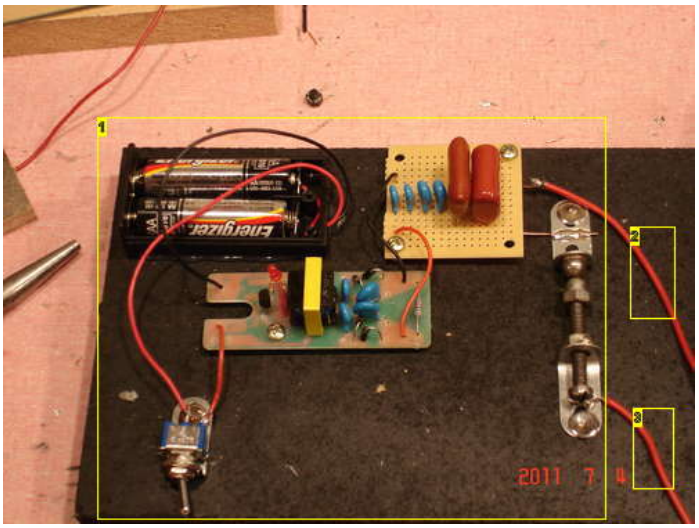


Image Notes
1. Entire setup so far
2. To flyback transformer
3. To flyback transformer

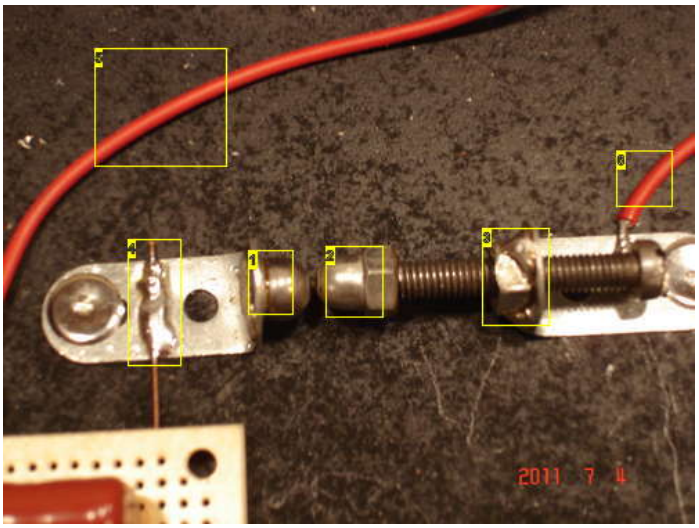


Image Notes
1. Ball bearing soldered to Erector set piece
2. Acorn nut
3. Nut soldered to Erector set piece to allow bolt to be screwed in/out
4. Feed from Capacitor bank
5. To flyback directly from capacitor bank
6. To flyback from spark gap

Step 5: Flyback Transformer

This is easily the most time consuming and tedious part of the build. While many other people might rewind their own primary coils on the flyback, I prefer to use the ones already available, since they are already nicely potted in the flyback. Unlike most flyback driver circuits, which use a primary and feedback coil, this just uses one primary coil. To find the primary coil, its down to trial and error. Using a multimeter, measure the resistance across each pair of pins. I find that in a majority of flybacks, the primary coils (as there are usually more than one) are situated so that their inputs are next to each other. That being said, this is not always the case. As you measure across each set of pins, take note of their resistances, as the one with the lowest resistance has the fewer number of coils. This is the one we are after. However, make sure that this is an independent coil, and that there isn't a third pin connected to it. Once this coil is located, the secondary coil needs to be located. Part of this is already done, since one "pin" is the fat (usually red) wire that comes out of the top of the transformer and has a suction cup on the end. The method for locating the second pin is relatively crude. Connect a 9 volt battery to one of the primary coil pins with an alligator clip, and to the other primary coil pin, connect an alligator clip. Don't connect this alligator clip to the battery yet. Take fat the red wire, and with the suction cup removed and the end stripped, place it close to one of the unused pins. Tap the disconnected terminal of the battery with the loose alligator clip, and look for a spark between the wire and pin. If there is none, move it closer and try again. If there is still no spark, move onto the next pin. If the wire doesn't spark to any of the pins, reverse the polarity of the battery and try the whole process again. Eventually, you will come across the pin you are looking for. Before disconnecting the battery from the flyback, take note of the polarity of the primary coil pins. If you are using one of the new flybacks, the polarity is important, since they contain a rectifier and voltage multiplier circuit. Once the primary coil is located, solder two long wires to it, and to the pin that the fat red wire sparks to, solder another wire. Then, just to be safe, pot the pins in hot glue. Make sure to use plenty of glue, and fill all gaps and spaces. This prevents unwanted arcing. Once this is done, the coil is all set.

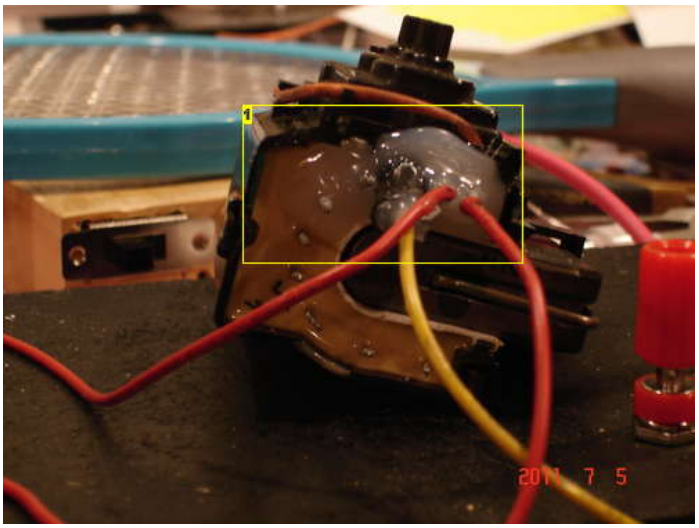


Image Notes
1. Pins potted in hot glue

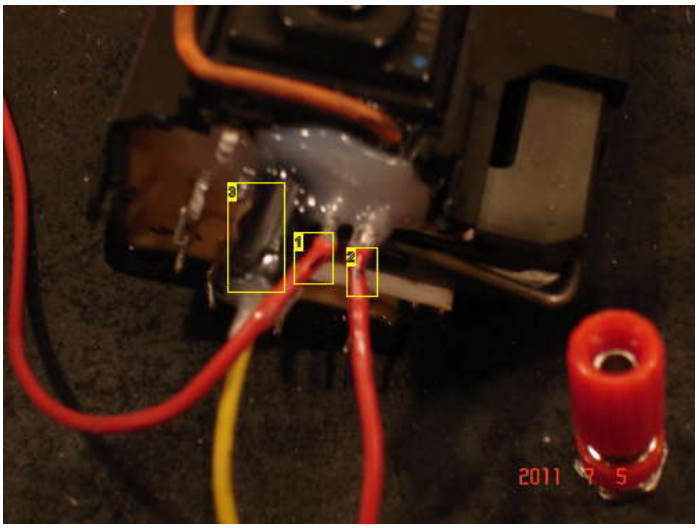


Image Notes
1. Negative input to primary
2. Positive input to primary
3. Second pin for secondary coil with wire attatched

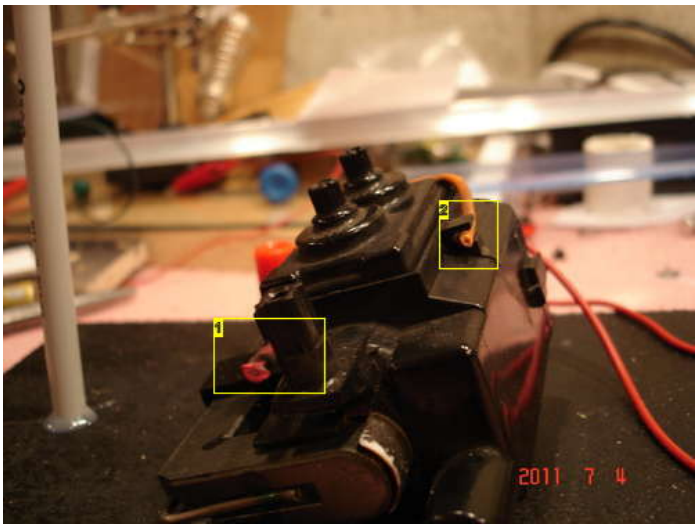


Image Notes
1. Unused wires can be trimmed
2. This wire too can be trimmed

Step 6: Putting it All Together

The flyback is now ready to be wired into the rest of the circuit that we prepared. In my circuit, the positive output from the capacitor bank goes thought the spark gap, then to the flyback. The negative output from the capacitor bank goes directly to the flyback. In this way, the spark gap is wired in series with the flyback. Once this is all set, the circuit is ready to be tested. flip the circuit on, and the red LED that was already on the zapper board should light up. This means the circuit is running and the capacitors are being charged. If you don't get a spark across the spark gap, check the width of the gap. If the electrodes are touching, back the bolt out (or however your spark gap is set up) until a spark is achieved, or if they are too far apart, make the gap smaller. DON'T MAKE ADJUSTMENTS TO THE SPARK GAP WHILE THE CIRCUIT IS ON!!!!! If you do so, you will be shocked. Once you have a spark, put the fat red wire close to the wire soldered to the other pin of the secondary. You should have an arc jump the gap. If not move the wires closer. If you get an arc from the secondary coil of the flyback, give yourself a pat on the back, your circuit is done! if not, time for troubleshooting. Check all connections, make sure the capacitor bank is charging by using a high voltage multimeter to check the voltage across the capacitors, check the spark gap width, check the polarity of the primary coil connections to the flyback, and check to make sure you are using the proper pins. Once the circuit is working, it's time to package it all up. Below, the picture is after its been mounted to a piece of mdf and a top load added, which is addressed in the next step.

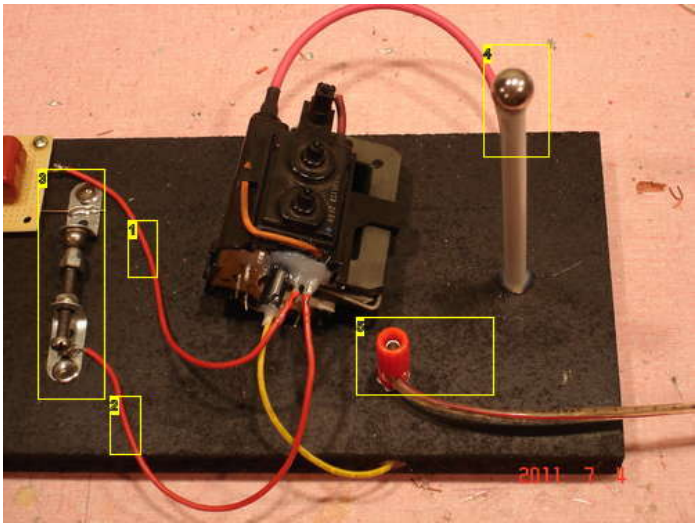


Image Notes
1. Negative input to flyback from capacitor bank
2. Positive input to flyback from spark gap
3. Spark gap in series with flyback
4. Top lad addressed in next step
5. Grounding post and wire addressed in the next step.

Step 7: Top Load and Mounting the Circuit

To make the circuit function more like a classic Tesla Coil, one end of the secondary coil needs to be grounded. This is done by simply attaching it to a grounding post or cold water pipe. The pin of the secondary that should be grounded is the one on the bottom of the flyback. The fat red wire is connected to the top load. The top load is simply something metal and smooth, without any edges or points. A large ball bearing works well for this. I then glued the top load to a plastic pen body, with the wire running up the inside. to make the whole set up neater, it was mounted on painted mdf (medium density fiberboard). The wire running to the top load enter the side of the board, then takes a right turn up inside the pen body. The other wire from the secondary coil enters the board from the side, but then connects to a binding post, so that a grounded wire can be attached to it. You can choose to do it as I have done, or mounted everything in a box, or however.

Using the "Tesla Coil": Turn the switch on, and with a grounded wire attached, plasma discharges will leave the top load. Because the discharges are low amperage, they are difficult to see in the light. In a dark room, once your eyes adjust, they are visible as white, mini lightning bolts. A wire can be attached to the grounding post, and placed near the top load, so it arcs to it. The longest arc I have recorded was about 3.6 cm long. The spark gap can be adjusted to achieve different results as well. Making the gap bigger leads to fewer pulses, as low as 1 a second, but leads to the most powerful discharges out of the top load. This is best when trying to achieve the largest arc to ground. Making the gap smaller leads to faster, but less powerful pulses. This is best for making plasma discharges into the air. Making the gap too small, however, will severely weaken the discharges. Finally, don't run the circuit for too long, no more than about 30 to 35 seconds at a time, as this can lead to the zapper circuit overheating and failing.

Congratulations on your new AA battery powered "Tesla Coil"!. Have fun with it, show it off to family members and friends, and experiment with high voltage! Remember, just remember to use common sense and be safe.

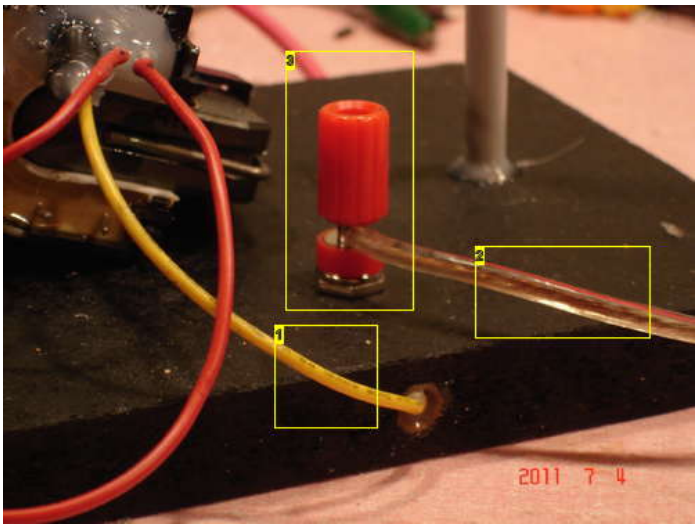


Image Notes
1. From secondary coil
2. Wire to groud
3. Binding post attached to secondary coil

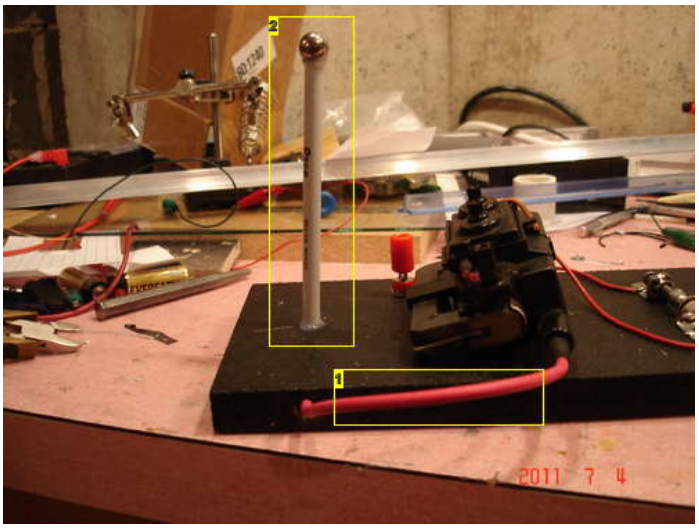


Image Notes
1. High Voltage output wire from secondary coil in flyback
2. Top load attatched to pen body

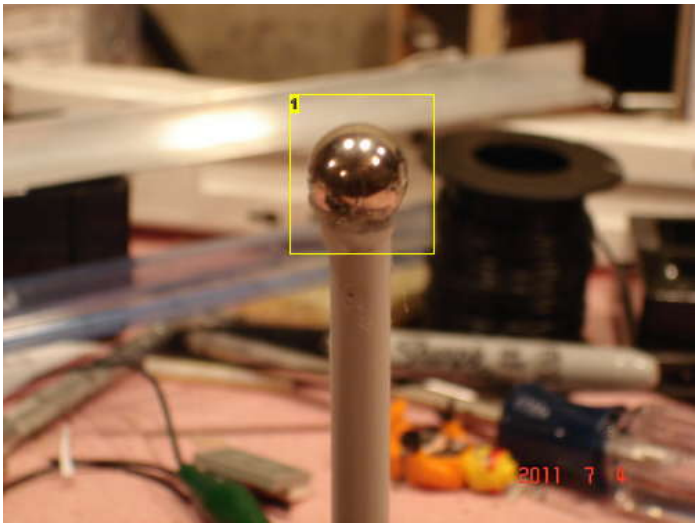


Image Notes
1. Ball bearing top load

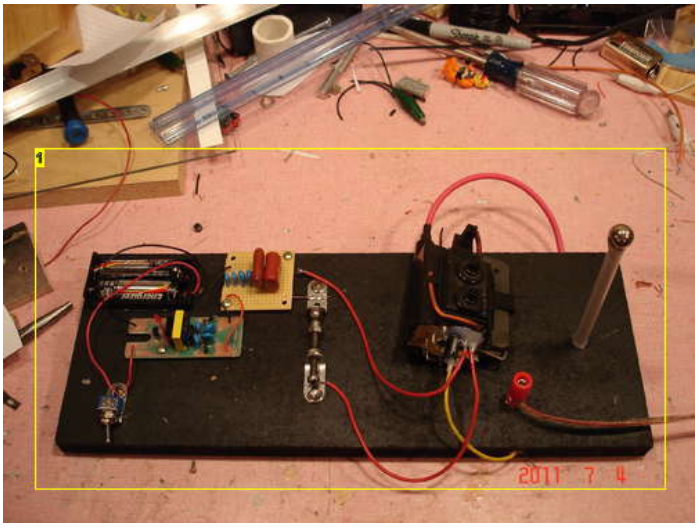


Image Notes
1. Entire setup all ready to go!

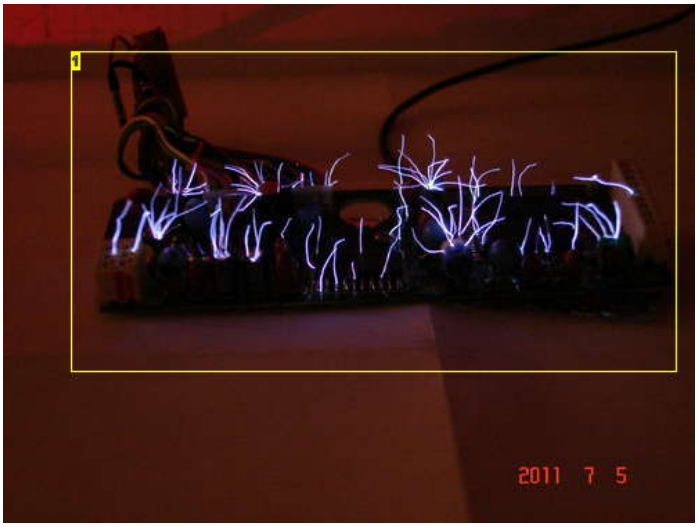
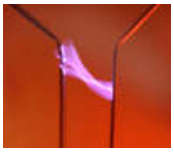


Image Notes
1. Time lapse photo of arcs from copper wire to a grounded circuit board

Related Instructables

How To Build A Simple But Powerful Flyback Driver by Plasmana



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Comments

34 comments **Add Comment**

Flying_MashedPotatoes says: Jul 7, 2011. 11:42 PM **REPLY**
even though ur only using 2 AA batteries, the voltage increases and is really dangerous???

JoeBeau says: Jul 8, 2011. 4:38 AM **REPLY**
Voltage doesn't kill you, amperage does. I remember reading somewhere that the average static shock is a couple kv or even higher, but the amperage is so low it doesn't hurt you. When a transformer is used to step up voltage, amperage goes down. If the voltage is doubled, amperage is cut in half. And visa versa- a decrease in voltage causes an increase in amperage. Here, three volts is increased to over 100,000 by use of transformers. That is 33,000 times higher, so in turn the amperage is 33,000 times lower.

jcansdale says: Jul 7, 2011. 4:37 PM **REPLY**
I'm trying to understand why grounding the secondary coil makes such a difference. Why do you get so much more voltage when the ground is attached?

JoeBeau says: Jul 7, 2011. 5:10 PM **REPLY**
You don't get a higher voltage necessarily, but by grounding it turns the secondary from a bipolar coil (Current feeding in a circular path throughout the coil) into a coil where the current feeds out of only one end of the coil. I cannot explain how this works or why too well, but all traditional tesla coils have one end of the secondary coil grounded. The ground is necessary to get larger discharges into the air. Without a ground, the discharges come out of both ends of the secondary coil. With one end grounded, all the discharges are focused onto one end of the coil. I hope that helps.

jcansdale says: Jul 8, 2011. 2:00 AM **REPLY**
Thanks for your reply - it's starting to become a bit clearer.

I noticed that connecting the ground triggered electrical breakdown (for a given gap) and a loud hissing noise. Larger discharges into air explains the hissing noise.

What puzzled me was the sudden breakdown. Won't this be caused by a higher potential difference? Why would grounding the system allow a larger potential difference to form across the gap? If anything, I'd have expected the larger discharges into air to make the system less efficient.

Still a little confused...

JoeBeau says: Jul 8, 2011. 4:31 AM **REPLY**
the grounding is necessary for making the discharges come out of the top load, like you see real tesla coils do on youtube. For making the spark just jump a gap from one output of the secondary coil to the other, a ground isn't necessary. When a ground is connected to one end, and the gap remains the same way as before, i have noticed that same hissing sound. That is the sound of corona discharges through the gap. With the lights out, you can see wispy purple sparks between the electrodes, or just the electrode tips glowing. If you use rounded electrodes for the gap, instead of just a stripped wire, you will reduce this type of discharge and have more "real" sparks. But i have noticed what you are talking about as well. It would seem that the ground being connected causes a larger potential difference, but i think instead it changes how the coil functions. It no longer a closed circuit through the coil, across a spark gap, and into the coil again. Instead, the circuit is from the ground, through the coil, and back to ground, which is the air, the ground itself, or you if you're not careful; anything that can absorb the charge.

pbman123 says: Jul 7, 2011. 9:51 AM **REPLY**
about how much would this cost to make? and how much experince is needed to make it

JoeBeau says: Jul 7, 2011. 5:30 PM **REPLY**
Experience wise, not tooo much. General soldering skills, as well as the ability to assemble, test, and troubleshoot a circuit. Because it is high voltage, it would be recommended to do some googling on high voltage safety precautions. A few would be to never work with a power supply connected (here that is the batteries) always wear rubber-soled shoes so you are not connected to ground, and to never touch a component connected to the circuit with two hands or be holding a ground in one hand while touching anything in the circuit. But this is a good beginners project for high voltage

JoeBeau says: Jul 7, 2011. 4:37 PM **REPLY**
It cost me about 5 bucks. I had to buy the racquet, but got the rest of the parts from old electronics. To buy everything new, you're looking at about 30 bucks, a huge chunk of that coming from the purchase of the flyback

hubi says: Jul 7, 2011. 1:30 PM **REPLY**
WoW cool Job,
nice High Voltage Device, I like it,
but it is not a real classic Tesla Coil design. Since there is an iron core and the primary to secondary coupling is much too high, but it does what a teslacoil should do.

JoeBeau says: Jul 7, 2011. 5:13 PM **REPLY**
I know it cheating to call it a tesla coil, but it does what a lot of people associate with tesla coils, and that is throwing the discharges out into the air. I called it a tesla coil mainly for descriptive purposes. Hopefully i can add another instructable dealing with real tesla coils.

hubi says: Jul 7, 2011. 1:34 PM **REPLY**
Sorry theres somthing more to say, the flyback you use is a modern DST with built in rectifiers, if you can find one you better use an old flyback with disc shaped secondary and no built in rectifiers.

JoeBeau says: Jul 7, 2011. 5:32 PM **REPLY**
That would probably help with some higher-voltage discharges, but the old flybacks are hard to come by. i'll keep my eyes peeled though.

JoeBeau says: Jul 7, 2011. 4:39 PM **REPLY**
I am working on a classic tesla coil at the moment, and once i get it working i'll post that as well. I have made a flytback driver out of a switch-mode power supply, and i hope to figure out a way to use that as a power supply for a tesla coil.

hubi says: Jul 8, 2011. 2:27 AM **REPLY**
why don´t you use the flyback output as powersupply for your real teslacoil??

JoeBeau says: Jul 8, 2011. 4:41 AM **REPLY**
That is my plan. the flyback puts out DC current, since i'm using a rectified one. I've been researching if this can still be used for a tesla coil, or if i need an AC current entering the capacitor bank and spark gap configuration for the resonant charging to work. Do you know if it will work?

The Lightning Stalker says: Jul 7, 2011. 2:09 PM **REPLY**
RTV silicone makes the best HV potting.

JoeBeau says: Jul 7, 2011. 5:01 PM **REPLY**
I know hot glue is faaar from ideal, but i wanted to make this as cheap as possible. i had plenty of hot glue, so i went that route. In the future though, if i am to build anything more powerful, i would definitely agree with you and get some real potting compound

menahunie says: Jul 7, 2011. 1:28 PM **REPLY**
This is NOT a Tesla Coil..
Go look it up..
This is the same as a car ignition coil and the voltage/amps can kill you...
100 to 200 mA or .1 to .2 amp IS FATAL

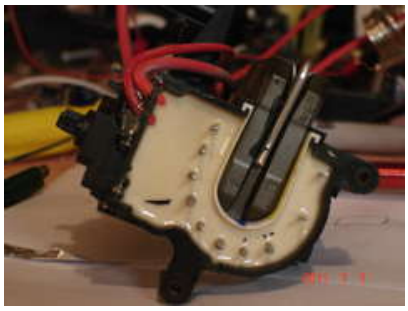
JoeBeau says: Jul 7, 2011. 4:56 PM **REPLY**
I know this isn't a tesla coil, as i stated in the intro, but all i was really after was the same effects as a tesla coil. I would like to build a real one some day. I do realize this is very similar to the ignition coil idea. For the amperage however, this doesn't produce enough to kill. with 3 volts from two AA batteries being stepped up to over 100k by the time it leaves the top load, the amperage from the batteries, even though it might have been close to enough to kill at the beginning, it is so low by the end the discharges would be more on par to a static shock. HOWEVER i would not recommend touching the top load just to be on the safe side, as i have not tested this idea.

ajinkyadixit says: Jul 6, 2011. 8:06 PM **REPLY**
very nice....awesome.....low cost project

JoeBeau says: Jul 7, 2011. 4:50 PM **REPLY**
The most bang for your buck was the whole idea behind this. I don't have much money to spend to make a real tesla coil, so i went as cheap as i could instead.

sooraj619 says: Jul 7, 2011. 8:14 AM **REPLY**
since the flyback transformer pins are glued, the pins cant be seen so please add pictures to show which are the pins nice job

JoeBeau says: Jul 7, 2011. 4:48 PM **REPLY**
The flyback pictured is a different one, and the pinout is different. The pin marked by the line is the other high voltage pin, and the ones marked by the single and double dots are the pins to the primary. But by comparing this flyback to the one in the instructable you can guess which pins are the ones being used in the instructable. Sorry, but i couldn't get a picture of the pins in the hot glue.



shobley says: Jul 7, 2011. 9:31 AM **REPLY**

How are you tuning the Tesla coil?

For it to operate at maximum efficiency don't you need to tune the LC primary circuit to the natural resonant frequency of the secondary coil?

JoeBeau says: Jul 7, 2011. 4:42 PM **REPLY**

For best efficiency, yes. But with this circuit design, the current entering the flyback comes as short pulses, and at a much lower frequency than the couple khz that a flyback normally operates at. It is certainly far from ideal, but works well enought for a simple, cheap project like this

nmaungboonma says: Jul 7, 2011. 10:36 AM **REPLY**

cool ~

RoboGeekDude12 says: Jul 7, 2011. 8:29 AM **REPLY**

When I find a flyback transformer (my dad just threw out like 3 old CRTs and a CRT TV D:), I'll be sure to do this.

aaricchavez says: Jul 7, 2011. 7:33 AM **REPLY**

I've always wanted a Tesla Coil, but getting/making a real one is expensive. Thanks, i'm gonna have some fun this weekend making this!

vishalapar says: Jul 6, 2011. 10:00 AM **REPLY**

Teslafying!!!!!!!!!!!!!!!Superb!!!!!!!!!Awsome job dome!!!!!!!!!!!!

5**********

Have a look at my ibles as well!

JoeBeau says: Jul 6, 2011. 11:03 AM **REPLY**

Thank you very much! I appreciate the feedback. Be sure to check in again for some more instructables. I'm planning some more right now.

vishalapar says: Jul 6, 2011. 11:18 AM **REPLY**

I just subscribed!Why not comment and rate my latest iblees as well?!

JoeBeau says: Jul 6, 2011. 12:17 PM **REPLY**

I took a look at some of your instructables and found the guitar hero keyboard to be absolutely epic. as you can tell from my instructable, i love using things for their unintended purpose. That ticks all the right boxes for a great and clever hack. i voted for it!

vishalapar says: Jul 6, 2011. 12:24 PM **REPLY**

Oh cool thanks for voting!!!!!!!!!!