Tesla coil theory and applications

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Contents

List of Figures

1 Introduction

1.1 Few notes on this document

This document is a *quick draft* introduction on tesla coils. I'll be telling something about tesla coil theory as well as practical construction. Info on both modern coils as well as of the original spark gap driven coils.

I have *not* ments this as a `make your own this one tesla coil project` type document. This is mainly denoted to the actual info although you'll be able to construct something based on this. This is mainly a manual for an experimenter who wants to know *what, where, when and why* on tesla coils.

No pictures are really accurate or drawn in scale. They are just illustrations and user should note this while reading this document.

User should never try constructing any projects described in this document. They can be dangerous for health and even couse death! All information is provided as is. User of this document should be very carefull and experienced in hi-voltage electronics to try anything out! If you do it the risk of any results is just yours. I take no responsibility of anything that might happen, let it be of a wrong information or anything else.

1.2 What is a tasla coil?

Tesla coil is a resonant high voltage transformer named after the inventor *Nikolai Tesla*. Tesla coils can be used to produce extremely high voltages (say 100kV or 250kV). Tesla coils can produce continuous sparks exeeding the height of the coil. Sparks will be very loud. Large devices can be louder than rifle shot! User should note this and be not suppriced with the first loud cracks.

Tesla coils can be used in experimenting with high energy electric and magnetic fields. Most bizarre efects will be noticed with tesla coils.

[1] Any additional info on subject is appreciated by the author

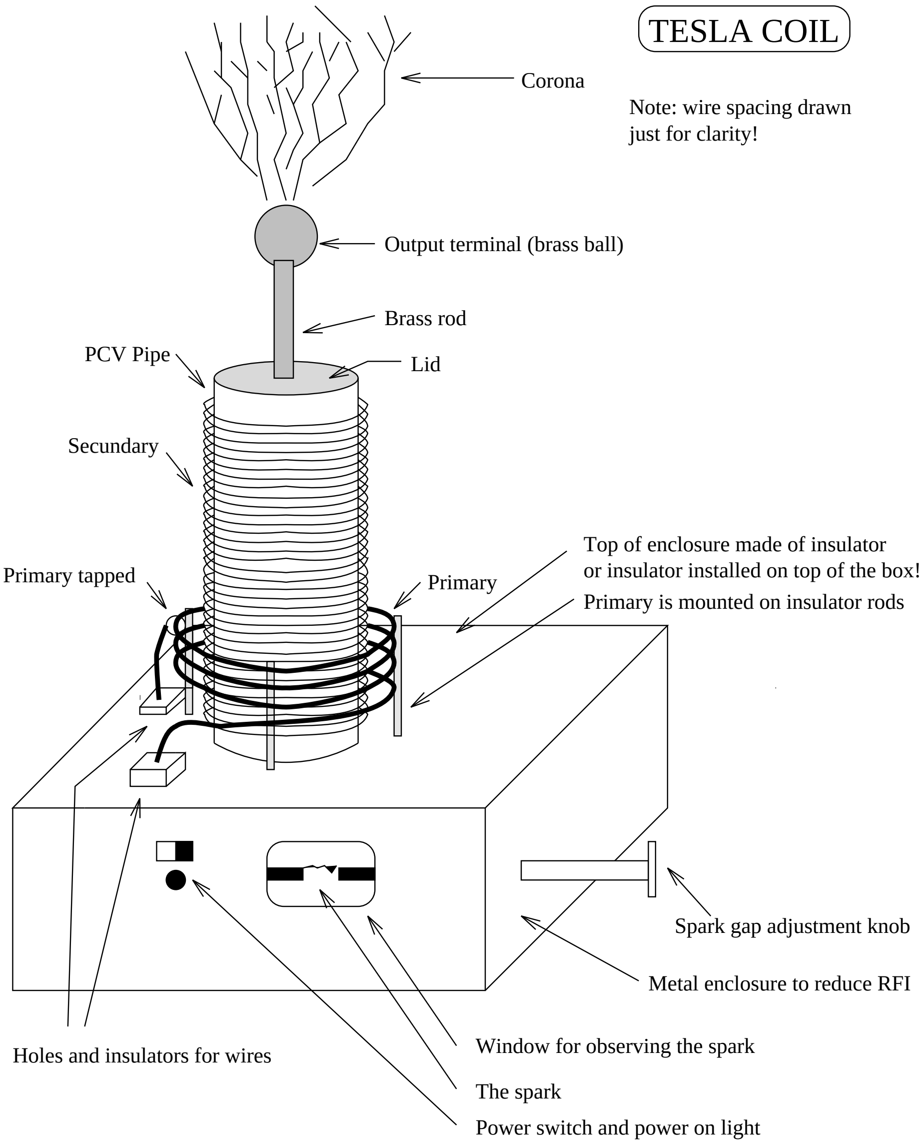
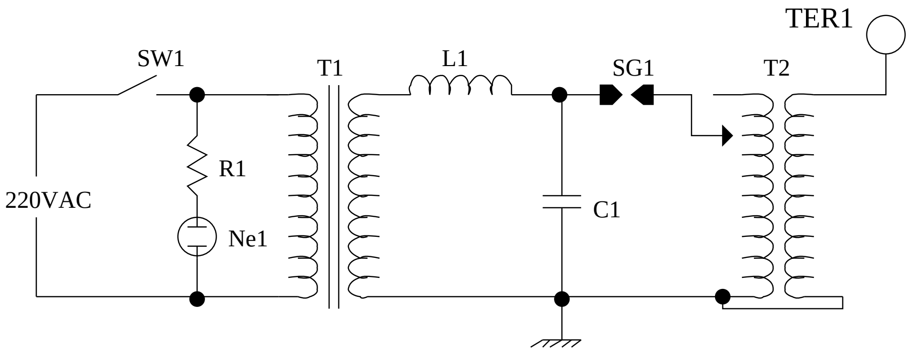


Figure 1: Whole tesla coil unit



R1 = 33k
Ne1 = Neon bulb
T1 = 6kV transformer (*)
T2 = Tesla coil (*)
L1 = 2.5mH rf choke, high voltage type
C1 = (*)
SG1 = Spark gap (*)
TER1 = output terminal (*)
SW1 = Switch

(*) = See text

Figure 2: Tesla coil schematics

2 General theory

Tesla coil is a high-frequency high-voltage resonant transformer. It differs from a conventional transformer in that the voltage and current relationships between primary and secundary are independent of turns ratio.

Usually tesla coil primary (see figure 2) has very few turns, say 6 or so. It is evident that it is capasitance dominant. Secundary of tesla coil is highly inductance dominant. Primary is tuned with the capasitor parallel with it. Secundary is tuned by self capasitance and inductance. Number of primary turns is used to tune the primary to the resonance frequency of the secundary.

Tesla coil should be driven in resonance. Force driving the secundary coil will produce hot spots and interwinding breakdown. The output of force-driven secundary is also lot lower than the output of properly driven (tuned) coil.

Tesla coil can be also driven at the resonance frequency. In this case primary does not need to be tuned. This is the case when coil is driven with an external oscillator or tuned interruptor.

3 A sample shematics

There is a sample shematics on the figure 2. R1-Ne1 is an power-on indicator. It could be replaced with an ordinary lamp if one wants to.

T1 is the step-up transformer. A 6kV/23mA transformer is used in [1]. A 10kV neon transformer is used in [2]. I'm about to use a 4kV/100VA and 8kV/200VA transformers in my projects very soon. One should select the transformer according to the needs again. Voltage rating of C1 should match the output voltage of T1.

L1 is there to reduce noice induced at the power line. You'd better off with a good noice filter instead.

T2 just steps the voltage up. T2 is the actual *Tesla coil*.

4 Some tesla mathematics

4.1 Output voltage

When coil is driven in resonence the output of tesla coil can be approximated by

$$V_{out} = C_1 V_{\text{in}} / C_2 \tag{1}$$

where

C_1 = primary capacitance
C_2 = secundary capasitance
V_{in} = the input voltage.

This could be expressed also as a ratio of primary Q and secundary Q[2] or by means of SWR.[3] Output voltage will be SWR times the input voltage where SWR is the ratio of transmission line impedance to the input impedance of coil.[4]

4.2 Resonance frequency

Resonant frequency of the primary can be easily calculated with

$$f = \frac{1}{2\pi\sqrt{LC}} \tag{2}$$

where

[2] I'd need more info on these methods! Tell me if you know!
[3] As suggested to me by Bob Hale.
[4] Maybe some books about transmission line theory would be helpful on this subject.. The author would love any additional info these methods!

f = the frequency in Hz
L = the inductance of secundary coil in H
C = the primary tank capasitance in F

The secundary is the difficult part to approximate. I've found the following method an exellent approximation for coils with h/d in range of 1-3. The frequency is determined by the inductance of the secundary and by the interwinding capasitance of secundary as well as by the capasitance of the output terminal. Effect of the output terminal has been negletted here.

The frequency is calculated from

$$f = c/\lambda \tag{3}$$

where

f = the frequency in Hz
c = the speed of light (300 000 000 m/s)
λ = the wavelength in meters

λ can be calculated from

$$\lambda = sl \tag{4}$$

where

s = the shape factor
l = the length of wire

λ and l are in the same units.

Shape factor is originally from a table. I just made an polynomial approximation to make calculations easier. See [5] for the original method. Shape factor can be calculated from

$$s = 3.485 \times (\frac{h}{d})^{-0.304} \tag{5}$$

where

s = the shape factor
h = the height of coil
d = the diameter of the coil.

I've found the approximation of frequency has been within 10% error mariginal with the coils I've constructed. A lagre capasitive hat will make a difference and it should be avoided anyway.

You can also calculate the frequency of secundary by

$$\frac{h}{\lambda} = 0.25 \times \sqrt{1 + 20 \times (N + d)^{2.5} \times \sqrt{\frac{d}{\lambda}}} \qquad (6)$$

where

h = the height
λ = the wavelenght
N= number of turns per unit lenght
d = diameter of the coil

According to Bob Hale this equation can be found in [3]. This method seems very accurate as well.

5 Construction of the components

5.1 The whole unit

A drawing of an operating unit is included. See the figure 1 for an example of constructing the whole unit.

5.2 Tesla coil

5.2.1 The Primary winding

The primary is wound at the bottom of the coil usually. I have found experimenting with the position of the primary may be worthwile. In some of my experiments feeding at the middle of the secundary gave better results. Constructing a bottom-fed tesla coil might be easiest to do like shown in figure 1.

Primary is naturally a bit larger than the secundary. Usually primary and secundary have something like 1-5 cm space between them to prevent arcing from the secundary to the primary.[5] See 5.2.2 on page 10.

The primary should be made of few turns (3-12) of heavy wire or even copper tube or any other highly conductive material. Primary should *not* be made of insulated wire. Tuning is made by tapping the primary on suitable points. Care should be taken that user cannot touch the primary by accident.

[5]This really does happen I've seen it!

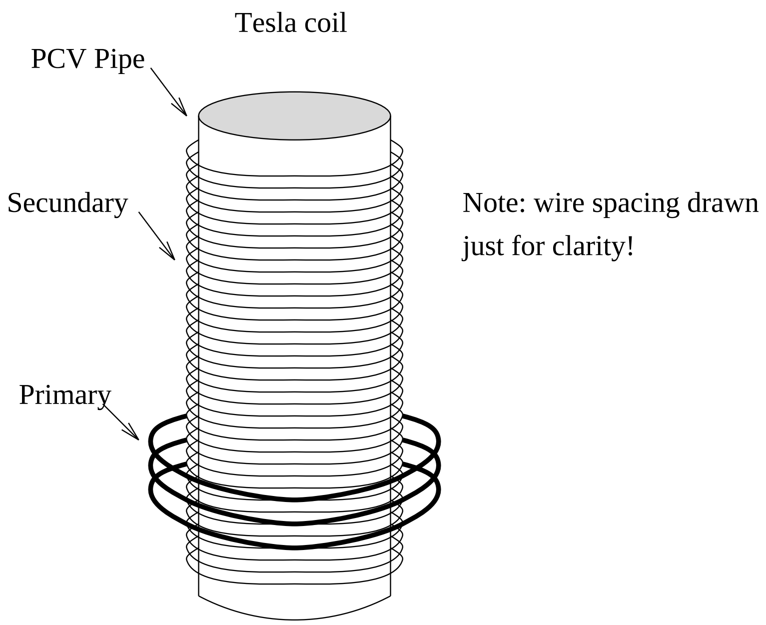


Figure 3: The tesla coil

5.2.2 The secundary coil winding

The secundary is a large **single layer** coil. It should be constructed on some non-conducting matherial, such as PVC pipe. Winding must be neat and tight. Any overlapping will affect performance dramaticly.

A multilayer coil is not possible. It would be too difficult to insulate the layers. Say you have some 200kV output. Then for a two layer coil the potential between the layers would be 100kV. That would be arching on the air over a distance of approximately 20mm or so. To avoid the huge insulating problems you'd better make it one-layer type. As well you can do frequency approximation for a one-layer coil with the formulaes described in this document.

After secundary has been winded it should be insulated properly. One could use something like plastic spray, silicon, paraffin wax and many other good insulators for that. One should observe any appearing corona on the coil and insulate it more or the coil will be destroyed. Arcing between primary and secundary can be reduced by putting a plastic tube between the primary and secundary.

See figure 3 for a picture. Note that it has very large spacing drawn just for clarity, it should be tight!

5.2.3 Secundary coil dimensions

This is the hard part for the constructor. The coild should be made with 1/4 wavelength of wire. Secundary should have lenght/diameter of approximately 2...2.3.

5.3 Primary capasitor

High voltage capasitors are hard to find and very expencive. Therefore it might be goot idea to make your own. There are lots of good ways to make capasitors.

To make good capasitors one should know some theory behind the capasitors. Capasitance between two parallel plates can be calculated from

$$C = \frac{\epsilon S}{d} \tag{7}$$

where

S = surface area of a plate
ϵ = dielectric constant
d = distance between the plates.

So, to make capasitors large (in capasitance) one should keep the distance as small as possible. Usually this is limited by break-down voltage of the used material. A better insulator will allow shorter distance and therefore more capasitanse and smaller size. Of cource, one should have bigger plates for more capasitance as well. Dielectric constants can be seen in the tables, see the local library.

You can make easily adjustable capasitors by changing the distance between the plates and by changing the effective surface area. Changing distance is rather easy, attach one of the plates to a screw. Modern (small) adjustable capasitors have plates (say the plates are half sphere shaped) which can be rotated. On the one extreme the plates are not at all between the others. On the other extreme the half spheres are exactly between the others. Therefore rotating is used to adjust the capasitance.[6]

5.3.1 Plate capasitor

Figure 4 has a conventional *plate capasitor*.[7] Aluminum foil could be in between of larger insulator plates. The insulators should be large enough to prevent

[6] Buy one and see, if you're still wondering how to do it!
[7] Note that drawing is again made clear, not correct. There is extra spacing for clarity.

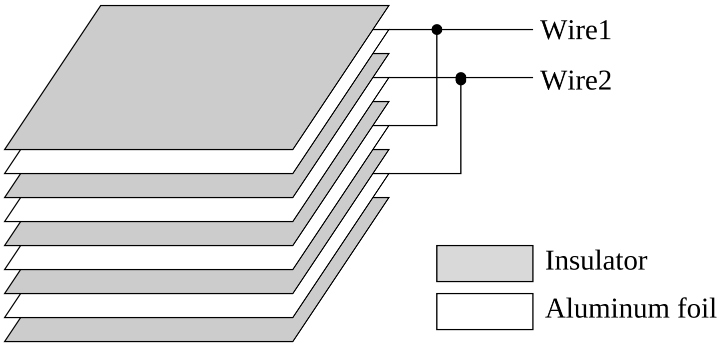


Figure 4: Plate capasitor

arching from one plate to the other. Of cource other materials like copper plates can be used as always.[8]

5.3.2 PCBs

Another way to make plate capasitor is to stack some PCBs and you'll have a plate capasitor described earlier.

Depending on what you want even a single doublesided PCB might be good.[9] All you have to do is to solder a couple of wires and there you are.

One should also etch an adequate spacing between the copper foil to the edge of the PCB. If not, there will be arcing from one plate to the other.

5.3.3 Layden jar

Figure 5 has a *Layden Jar*. It is very easy to make like all capasitors.

Take an old glass jar and attach aluminum foil on the inside and on the outside. Nicolai Tesla himself used layden jars as capasitors.

According to [2] a layden jar with a diameter of 135mm and foild height of 100mm will have a capasitance of almost exactly 1nF. One should note that the jar has to have the cap on or breakdown may occur.

[8] I leave the choise of the material for the experimenter.
[9] This approach has been used every now and then for small capasitors

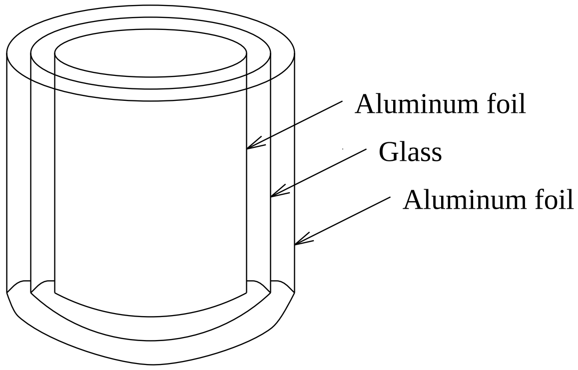


Figure 5: Layden jar capasitor

5.4 Output terminal

5.4.1 Capasitive hat

Output terminal is often called a capasitive hat as well. It should be a brass ball attached to a brass rod. It should not be too large or output will be reduced. Something like 3cm in diameter is said to work well.

In figure6 we have a picture of an output terminal. There is a lid glued on top of the coil core (PVC pipe). This lid should be insulating material of cource.

Drill a suitable hole on the lid and mount a brass rod on top of the lid. On the end of brass rod you should attach the brass ball. The wire from the upper end of the coil is attached to the brass rod. Drill a small hole at the side of the pipe. You have to get the wire inside somehow of course.

You better insulate the wire and the lower end of the brass rod. (Not drawn in the picture.)

Alternatively you can mount a banana plug at the lid an just install brass rod on it. This anables you to experiment easily with many different kind of terminals.

5.4.2 Other output terminals

You can try many different kinds of terminals. You can try just plain wire, a kneedle and so on. Probably the most spectacular terminal is a so called *rotor* which is also shown in figure 6. The electrons will be shot off from the ends of the rotor. Becouse of the finite mass of the electrons it will start rotating. *Rotor* should be carefully balanced to work. This is also called as *an ion motor*.

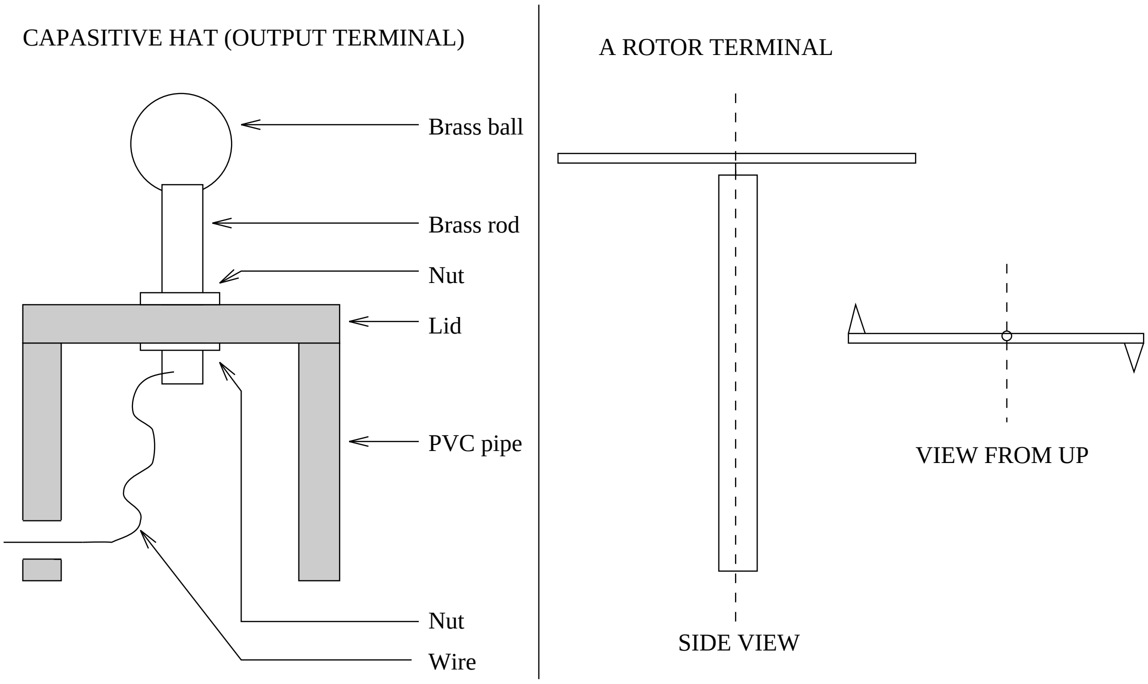


Figure 6: Output terminal

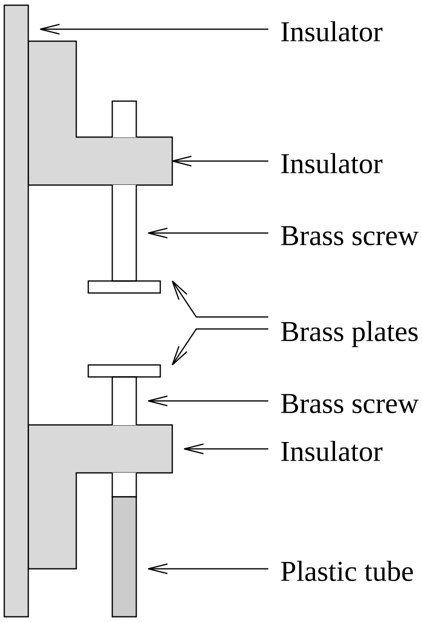


Figure 7: Spark gap

5.5 Spark gap

Spark gap should be constructed of two parallel plates with adjustable distance. One of then is usually solid and the other is attached at the end of a bolt which could be rotated to adjust the distance. It could be also made of just an adjustable gap made for example with two brass rods.

In figure 7 we have two parallel plates attached to screws. One screw is fixed and one can be turned by the plastic tube attached to it. As with all the high-voltage components one should take great care not to place any objects near the metal enclosure. Arching will occur if you do.

Some early high power radio transmitters used rotating spark gaps to reduce erosion. The principle is shown in figure 8. The motor rotates the rods attached to it and spark occurs only when two brass rods are closely enough. Sometimes a very large number of rods were used. Something like 50 or even 100 was not very uncommon. Aside from reducing the erosion this type of spark gaps used to have a better note on the receiver.

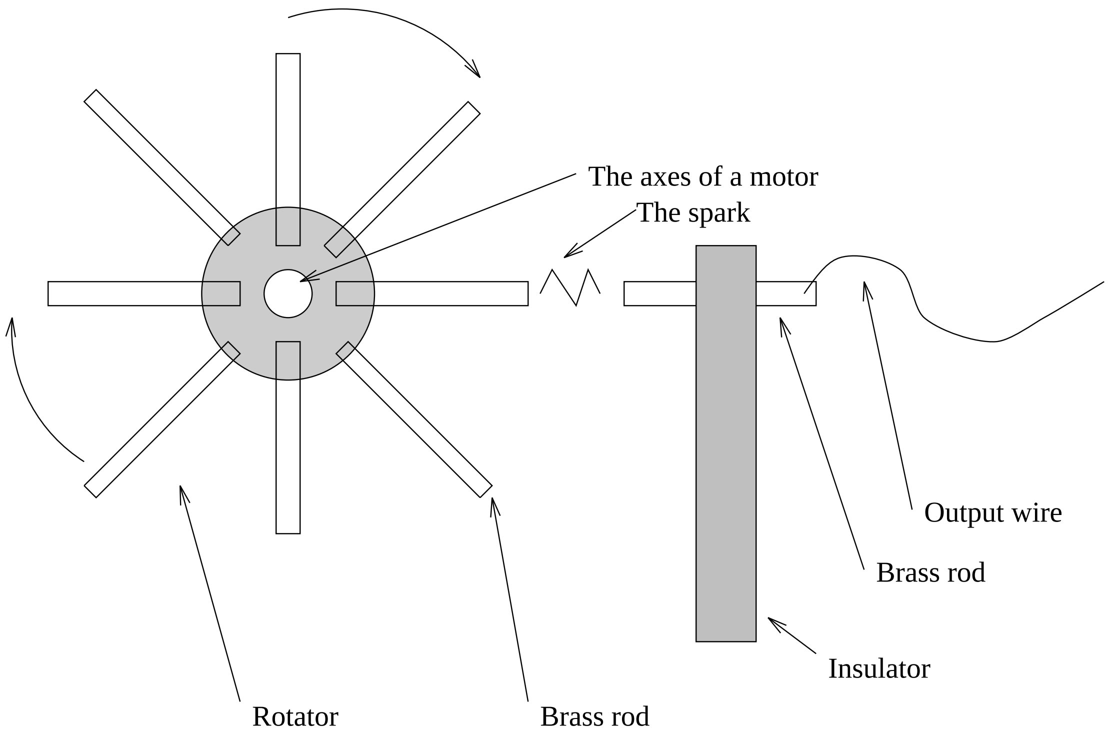


Figure 8: Rotating spark gap

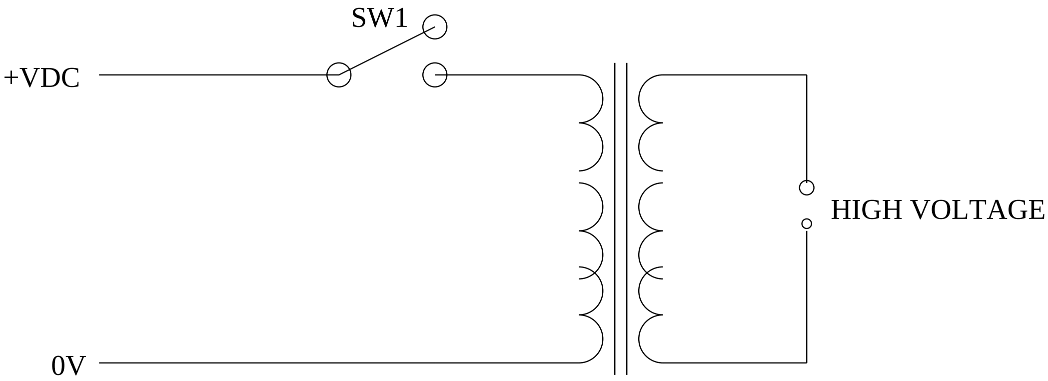


Figure 9: Interruptor

5.6 High voltage supply

5.6.1 High voltage transformer

By far the most versile high-voltage supply is a single transformer connected to mains as shown in the sample shematics. This very simple to make and rather cheap if you run into some surplus neon transformers.

5.6.2 Mechanical interruptors

There are many ways to make mechanical make/break type supplies. These were used in the early days of tesla coils. Figure 9 has a shematic for an interruptor based system. SW1 can be a mechanical switch or a relay. Most usually SW1 used to be a swich which could be rotated with a motor.[10]

Some early interruptors used a metal triangle attached to a motor. As the triangle rotated corners were dipped in the liquid mercury and contact was momentarily made. *Reader is adviced not to try this method becouse mercury is highly toxic!* This type of setup can be seen in figure 10. The triangle is used as a one end of the “swich” and an electrode at the mercury is used as the other end of the “swich”.

5.6.3 Electrochemical interruptors

Some electrochemical inturroptors have been used in the early days of tesla coils as well. The best known is *the Wehnelt interruptor*. It is very eaysy to construct

[10]This type of induction coils are still used in the car ignitation system

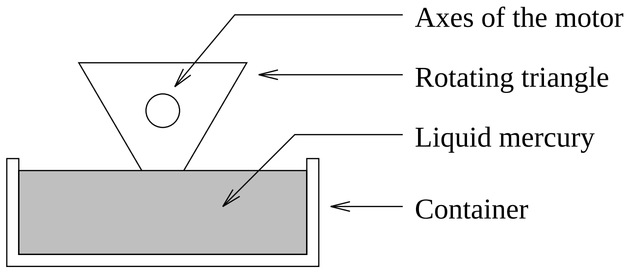


Figure 10: Mercury based interruptor

from two plastic containers. Needle valve is not essential for the operation. See figure 11 for an illustration of this type interruptor.

5.7 Resonance indicators

There are lots of nice methods to see when the coil is tuned. These include

- Series ammometer
- Other current indicators like LEDs
- Monitoring the output corona
- Monitoring the output magnetic field

All of these are commonly used and are rathre easy to construct. Yet the are very valuable for the operator and tuning of the coil.

5.7.1 Current measuring

This principle inscluded both using a ammometer and using a LED as a tuning indicator. A current indicator is just installed between the *low voltage end* of coil and ground. Using a LED as a tuning indicator is shown in figure 12.

A few words about figure 12 has to be said. Diodes D1-D3 are in series. The voltage across them is about 1.8-2.1V. Therefore the LED D5 is lit when the current is running from ground to the coil. When the current is opposite diode D4 conducts and current is running to the opposite direction.

It should be noted that whereas voltage is high the current running through tesla coils is low and therefore this kind of method can be used. I've tried it for a rew times and it seems very reliable.

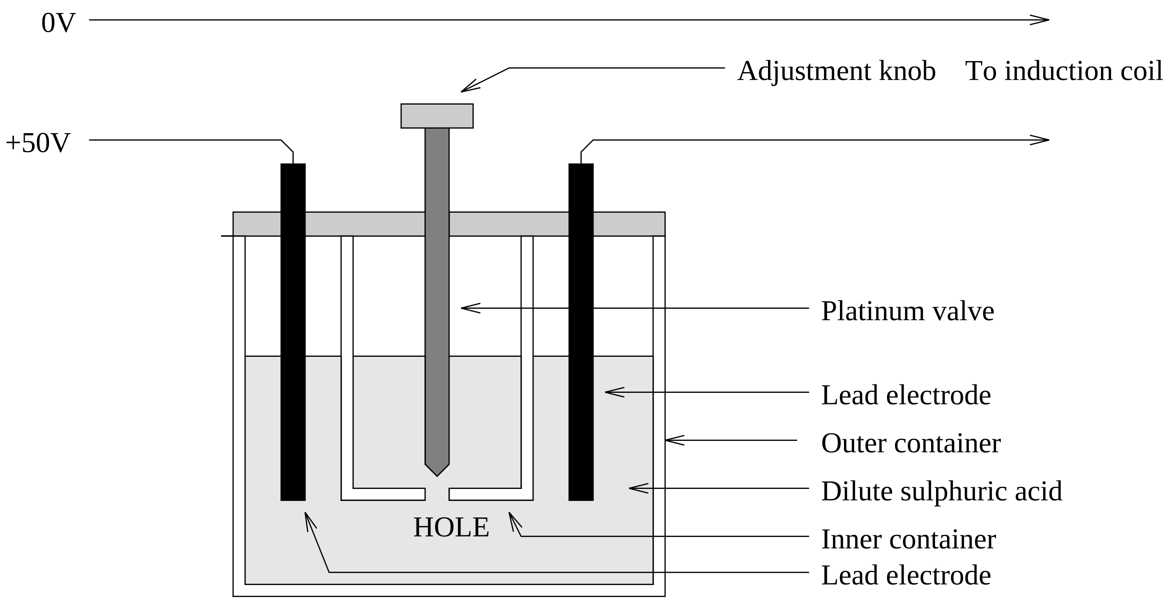


Figure 11: Wehnelt interruptor

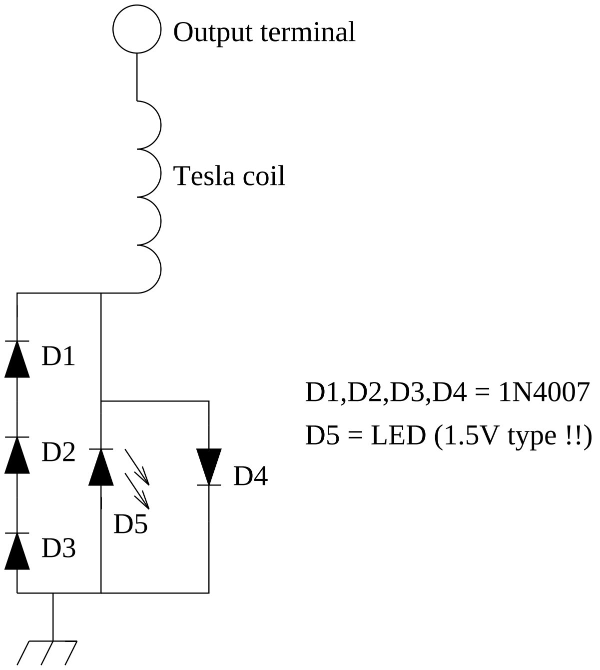


Figure 12: LED as a tune indicator

The current when operating the coil can be too large to see a very good difference in the led. One should run the coil with a lower power (lower input voltage or limited input current) to reduce the output. In that case the coil is dim enough and differences can be easily noted.

Of course, you can replace LED and diodes with a current meter. I've not tried this ole out (yet) and thererefore I will comment it no more. It has been used in the early days of radio and still almoust every radio amateur wants to measure output power every now and then.

5.7.2 Monitoring the corona

Monitoring the corona output is the best method for fine tuning the coil. One just has to observe the corona and tune the coil for best possible output. No extra hardware is needed either.

Other methods are very usefull for coarce tuning the coil. Finding a optinum tap location can be sometimes difficult and when monitoring the current one can see if the change is going to the right direction. Naturally, once the tap is found corona can be observed for fine tuning.

5.7.3 Monitoring the magnetic field

I run the coil with low power becouse one should always run the coil with low power when coarce tuning it. A 1-2 turns large *big* loop was installed 10cm below the tesla coil to pick up the magnetic field. A small resistor was added in parallel with the loop to load it slightly.

Then I monitored the output with a oscilloscope. I noticed that the coil acted as a good filter and almoast only the resonance frequency component was noticed as a clean sine wawe. When the driver section was not tuned very accurately the output was low. Then I monitored the output and tuned for a maxinum ampilitude.

This method may sound difficult. However, it is very easily constructed and it proved to be very reliable. It made the tuning process very easy! Of course, not everyone has a scope and they are forced to use other method. A current meter might be one good alternative.

5.8 Materials

I'm telling all the time you something like plastic, brass, steel, aluminum, glass and so on. I'm sure you can figure out the meaning of these. Select materials according to you're need. You can use silver if you want and need the better conduction and can afford it. Usually brass will do and sometimes even steel will do. The insulating materials can be selected according to your need as well. If you want small plate capasitors you need better insulator. Usually glass of PVC of teflon should do. The choice is yours. See A on page 28 for details on materials.

6 Construction, the practical aspects

As I said already, you should bear in mind that high voltage arcing can occur in the air. You'll need usually something like at least 1-2cm space between different conducting materials. If you run you're coild with a higher voltage, you'll need bigger spacing naturally.

See the bibliography for better info on the construction of those coils.

7 Sample coils from bibliography

[1] used a coil made of #24 wire. Coil was 10" in height and 4" in diameter. It had 500ft of wire and approximately 450 turns. The primary was made of 6 turns of #12 wire wound as a loop with 8" in diameter. C1 was 5nF. Output with 6kV input was approximately 10" sparks. Operating frequency is not mentioned.

[2] used a coil made of 500 turns of 1.5 diam wire. It was close wound so that windings occupied about 750mm of of a 900mm tube which had 70mm diameter.[11] An 200mm diameter primary consisted of 12 turns of heacy wire of which normally about 6 turns were used. Primary capasitance was 2nF and the frequency was about 300kHz. The output was approximately the same as in the previous. Note that larger coil and higher voltage did not work any better becouse the shape was not good.

[2] used a spark gap made of only two brass rods. I'm still wondering if the plates are usually there just to reduce erosion...

8 Modern tesla coils

8.1 General discussion of modern tesla coils

Modern coils are usually driven by different kinds of oscillators. One could use a MOSFET, bipolar transistor or a tube to drive the primary. Usually the configuration is push-pull to get more output.

[11] This was the original coil made of Mr. Tesla. Note that this does not have the best possible shape!

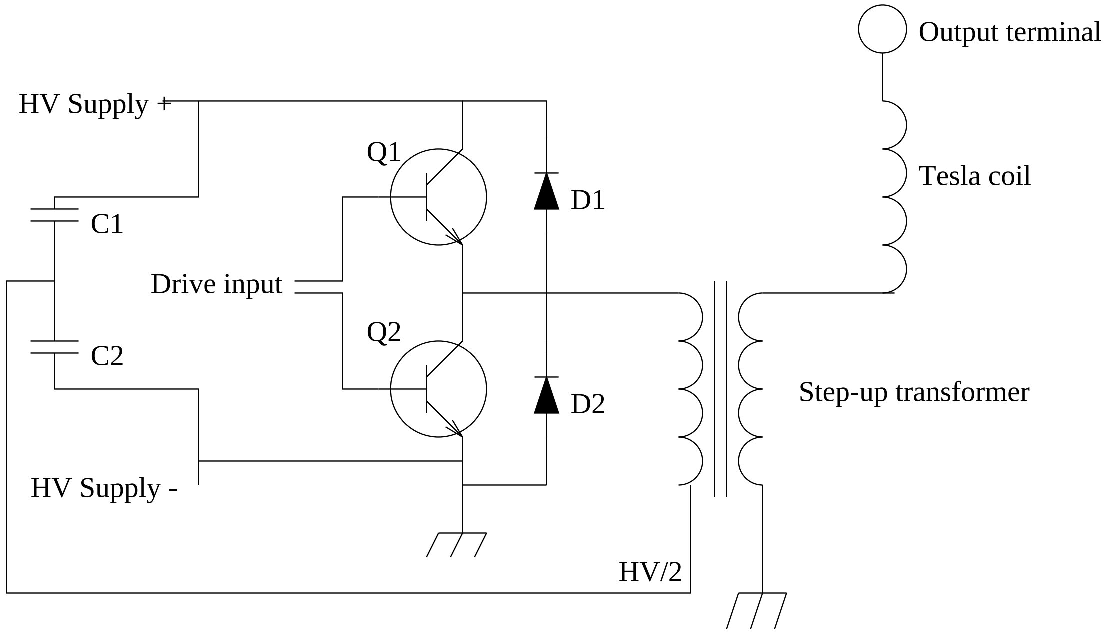


Figure 13: Push–pull driver with step-up transformer

Tubes are far most the best choice. They are not as sensitive to spikes as transistors are. Therefore they are harder to distroy and less precoutions is required. There are also tubes for very high voltages (in the kilovolt range).

This kind of driver could be constructed in two ways: One way is to have a simple push-pull oscillator which drives the coil. The other way is to have a separate oscillator driving the power stage.

8.2 Push-pull configuration

The [4] had basically a method similar to that in figure 13. The main idea is this: One end of the primary of the push-pull transformer is at half the supply voltage. The other end is pulled to low and high alternatively *at the resonance frequency*. The transistors T1 and T2 are driven by some sort of oscillator (not shown in the figure). D1 and D2 are there to protect transistors from voltage spikes.

Another way would be driving it directly like shown in figure 14. This could be done, if you have very high supply voltages. In practice with high voltages you will have to use tubes instead of bipolar transistors.[12] The main idea is this: T1

[12] Tubes are easily found for 4kV whereas even 2kV transistors are rare and expencive

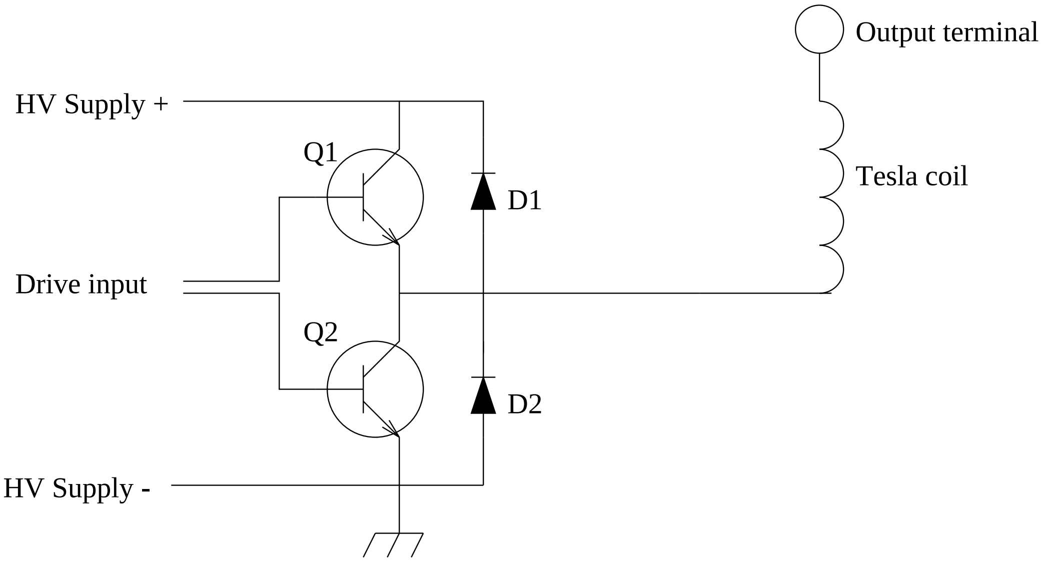


Figure 14: Push–pull driver with direct electrical connection

and T2 are pulled alternatively low and high *at the resonance frequency*. The driver is driven by an oscillator and diodes D1 and D2 are for protection like in the previous example.

Of cource in either of these methods you could connect the output of the driver to the primary of tesla coil in case you want to drive the coil inductively. However, I prefer electrical connection.

Push pull configuration can be driven by sine oscillator or by square wave. Square wave may be preferrable becouse it will result in less heat in the driver transistors/MOSFETs/tubes when these are driven into complete conduction. Dispite of the disadvantages of driving with square wave it may be desirable or even essential to keep the power dissipation low.

The drawback of square is that it needs more power than the sine becouse only some of the power is fed at the resonance frequency. According to the fourier theory square wave can be expressed as a series of sines. For example, a square wave with a frequency of $1/(2\pi)$ and values of 0 and $2k$ (lo and hi) can be expressed as

$$f(x) = k + \frac{4k}{\pi}(\sin x + \frac{1}{3}\sin 3x + \frac{1}{5}sin5x + ...) \qquad (8)$$

Therefore it is evident that only part of the fed power is on the resonance frequency.

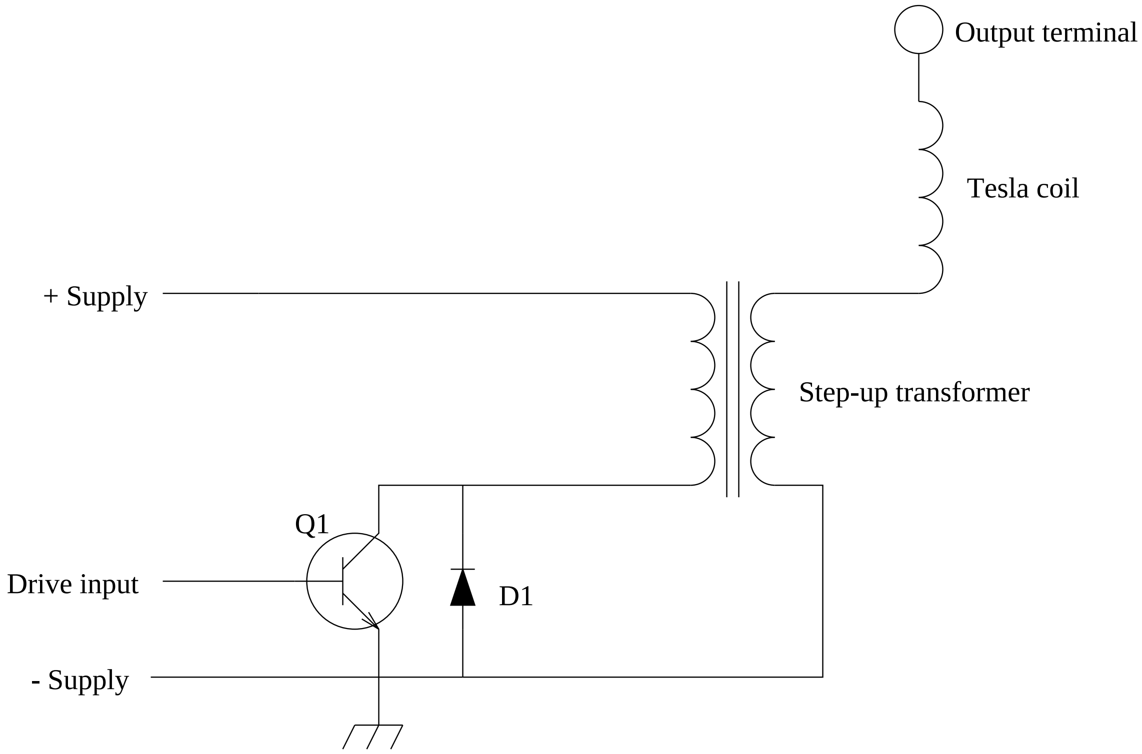


Figure 15: Single ended solid state driver

8.3 Single ended driving

My first experiments were made with a single ended driver like shown in figure 15. This is also driven by some sort of oscillator. I used 555-based oscillator in my first prototype. Almous any stable and tunable oscillator should do. This type of driver should also be driven at the resonance frequency.

If this type of driver is driven with square you will get huge spikes at the primary of the step-up transformer. There is no protection devices drawn at the figure 15 but user should install something like a *fast* zener diode or a MOV parallel with D1. The spikes can be reduced also by installing a small capasitor parallel with D1. Tubes and MOSFETs can be used in the place of bipolar transistor Q1 as well.[13]

[13] In fact I have used both bipolars and MOSFETs in the described configuration in my early prototypes

8.4 Practical examples of modern tesla coils

I used a couple of MOSFET and bipolar driven coils in my early prototypes. Due to various problems the prototypes were never converted to high-power versions. With 50VAC input my best prototype was able to produce 5cm sparks.

It was made with a singe mosfet oscillator which took feedback from the coil inductively. The coil was made of 0.315 diameter wire on a 16cm diameter PVC pipe. It had approximately 1000 turns and the height was approximately 37cm. After testing that I switched to conventional spark-driven coils. I'm still testing and more info will be added later on.

Another practical example comes from [4]. It had a push-pull configuration transistors driving a 110V:4kV step-up transformer which was directly coupled to the tesla coil. The tesla coil was made of 0.3mm diameter wire and it was 10" in lenght and 11" in diameter. Although the coil was huge and the input was 4kV it had only some 100kV output.

9 Modern vs original methods

The original method showly charges a capasitor and all the power is used in a very short moment. Therefore the avarage power will be rather low although the peak power at the moment of corona are extremely high.

The modern oscillator on the other hand uses power all the time. Usually oscillator is driven by half-wave rectified AC from mains to keep the avarage power consupsion down. The avarage power consuption for same results as the spark gap driven coil is larger. A spark gap driven coil is therefore a lot better.

The avarage power consuption is also noted as stressing the components. High avarage power means high stressing of components. Therefore the original coil is better also.

The peak power of spark gap coil is huge. Just think of few low-resistance caps in parallel in the primary and a primary coil made of 1cm diameter copper pipe. The peak current will be huge. Keep in mind that magnetic field is dependent on dI/dt where I is the primary current and t the time. The original coil will just have huge currents with its primary and therefore the magnetic field will be larger and the output will be higher.

With a spark gap driven coil you can easily drive it with say 20kV input voltage. With transistors or tubes that just would not be possible.

All in all I think the spark gap driven coil is a lot better than any modern coils (including the vacum tube coils). It is more of mechanical construction and less the electronics.

10 Experiments with the tesla coil

10.1 Precoutions

Tesla coils were used originally as radio transmitters.[14] Therefore it is evident that they will couse lot of radio frequency interference. Tesla coils should be operated in a room with a Faraday screen. It should be avoided that tesla coil would work on a frequency of any high inportance.

There are high voltages at tesla coils. If possible the user should have some sort of insulator around the primary winding. The sample unit shown in one of the drawings has no insulator. A plastic box could do very fine. Tesla coils should never be operated so that a user can have a nasty or even dangerous or a deadly electrical shock from the unit. The unit should be grounded for protection as well.

The unit described in [2] had no insulation on the primary and it was very dangerous to use. It was a replica of the model used by Nicolai tesla at his lectures during 1891 to 1893 in UK. The unit described in [1] has no insulation either. However I think the shield should be added on both cases for the sake of users safety. (Just think of 6kV or 10kV running on open uninsulated wires!)

User should note that high voltage electrons (higha speed electrons) have some uses one might not think of. One is to slow them down (very quickly) by shooting them at suitable metals (such as iron). X-ray radiation will then occur. User should note this. Some materials like aluminum (used at fluorecent tubes, for example) will not radiate X-rays and can be used safely.

10.2 Suggested experiments

Apart from the experiments with the different output terminals described earlier there is lots of fun to do with your tesla coil. Good things to try include

- Experiment with insulators. Nothing seems to help with tesla coils. A few millimeters of PVC just does not appear to have no effect.
- Effects with partial insulators such as wood. With wood you should notice the rea steaks and other bizarre phenomena occurring from *within* the wood.
- Put a paper on top of the output terminal. The corona is will just burn a small hole on the paper

[14] They were actually very poor compared to modern resonant antenna transmitters

- Hold a neon tube at hand from one end. It should glow within a few feet distance of the tesla coil. A good example of energy fields. No wires are connected!
- Hold a piece of metal *tightly* in your hand. Touch the corona or the output terminal with the metal object. This is an example of *the skin or surface effect* of high frequency electricity. *Anyone with a weak hart or anyone not in a very good psysical shape should try this, just in case. Also note that the unit should be tuned or a nasty shock will occur.*

I'm sure you can figure out lots of other fun experiments to do with your tesla coil. I have.

11 Suggested bibliography

Mr. Paul Prescott wrote in rec.radio.amater.misc group[15]

> The best single source for information about Nikola Tesla, Tesla coils, and similar apparatus is: *Lindsay Publications, Inc., P.O. Box 12, Bradley, IL 60915-0012*.
>
> Lindsay's offers primarily reprints of books and other information concerning technology and techniques no longer in general use.

I have personally no experience with this source.[16]

Internet users can also contact ARRL Info server at info-servarrl.org for some info on subject.

Bob Hale told me in private mail exchange

> *Vacuum tube tesla coils* by Corum has a fairly good theoretical treatment of Tesla coils which is not limited to vacuum tube types.

I haven't read this one either, I just have not found it (yet). [17]

[15] This is one of the newsgroups at the Internet
[16] Anyone got a phone and fax number for them?
[17] Anyone know the publisher and/or ISBN number or perhaps even a source for the book?

A Physical data

Some physical data is always needed by the constructors. I've included some inportant and usual ones here.

Material	resistivity Ωm	relative permeability	breakdown voltage kV/mm
Acryle	10^{15}	3.0	20
Bacelite	10^{11}	7	10
Air	??	1.0006	4.7
Glass	5×10^{11}	7	15
Nailon	10^{11}	3.8	18
Paper	$10^{10}...10^{14}$	5	15 ... 30
Polyethene	310^{15}	2.3	18
Polystyrene	10^{14}	2.6	20 ... 28
PVC	10^{12}	4.6	25
Teflon	10^{13}	2.0	35
Water, distilled	5×10^{3}	81	30

References

[1] R. E. Iannini, Build your own laser, phaser, ion ray gun & other working space age projects, Tab Books Inc, 1983

[2] Electronics Today International, June 1990, *Nicolai Tesla2*

[3] Reference dta for radio engineers, edited by ITT

[4] Radio Electronics, September 1991, *Solid state tesla coil*

[5] G. R. Jessop, VHF UHF Manual, fourth edition, the Bath Press, ISBN 0900612630