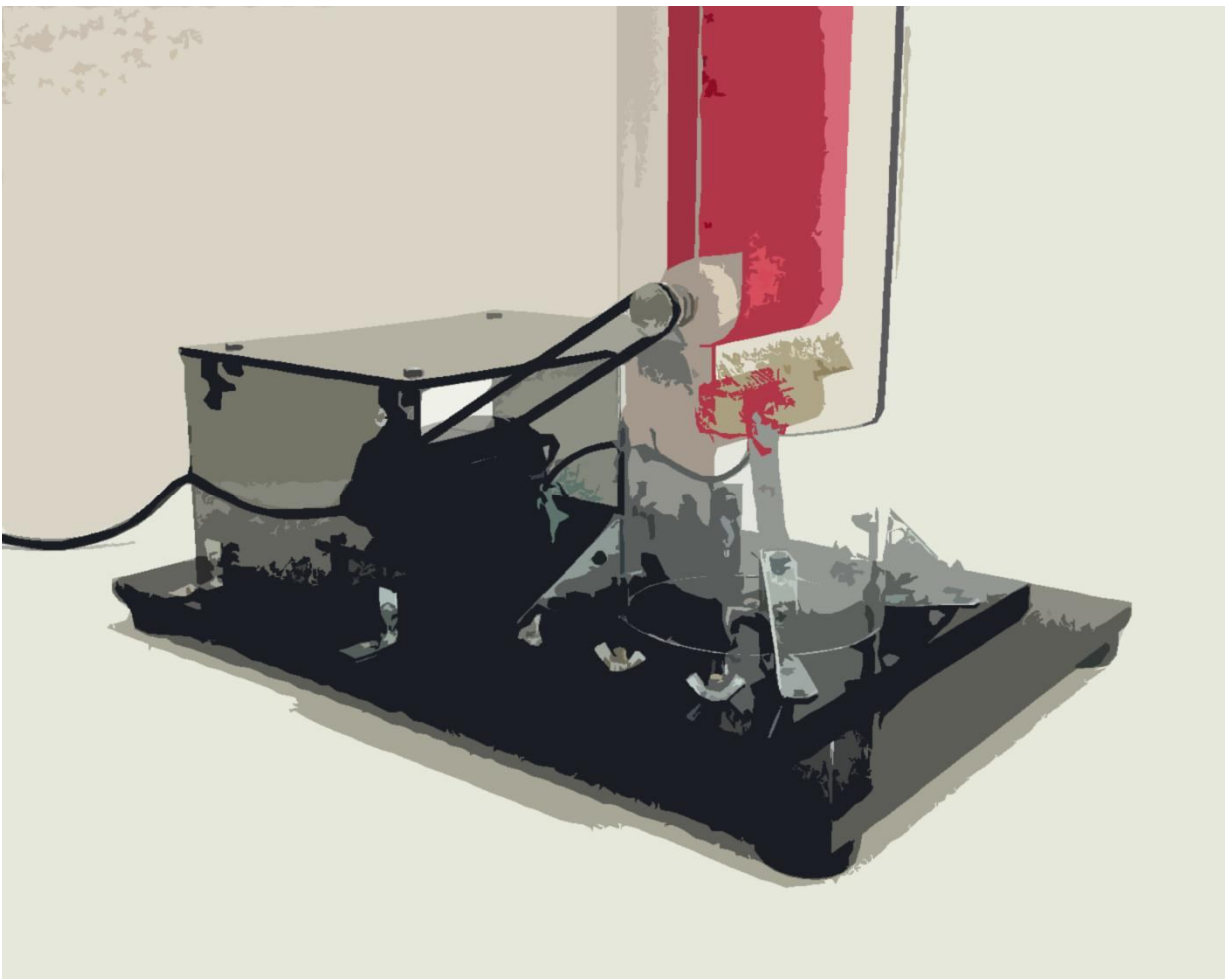




700KV Van de Graaff Generator Kit Instructions



700KV VDG KIT

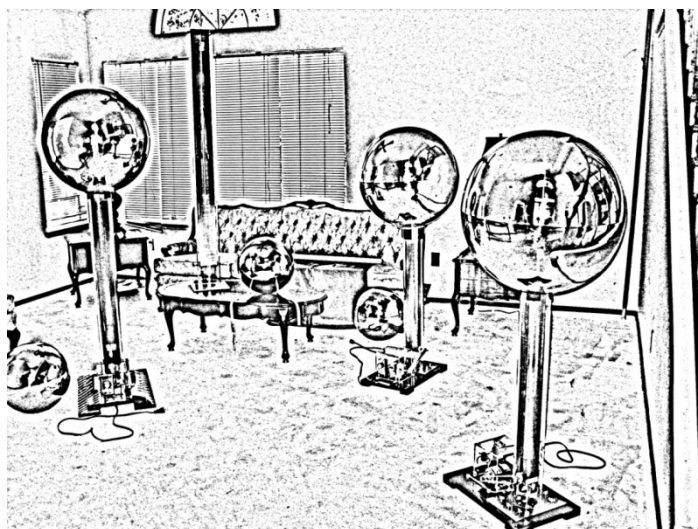


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Introduction:

Welcome to perhaps what will be your first VDG build. This manual is designed to give you a very straight forward streamlined set of instructions so that you will be finished and shocking your friends in no time. To start the build, below you will find a list of materials, tools and general adhesives that are necessary for completion. I encourage that you take your time to ensure a kit that will operate at its maximum performance.



During the process of constructing the VDG, there are a few things that are imperative to be mindful of. The first is to never get oil on any of the parts, primarily the belt and rollers, because this will hinder the device from producing a charge. Secondly, never clean the VDG with acetone or other alcohols because it will react and crack the acrylic, furthermore, acrylic is very fragile so be extremely cautious while handling. With these tips in mind, let's get busy.

Tools Needed

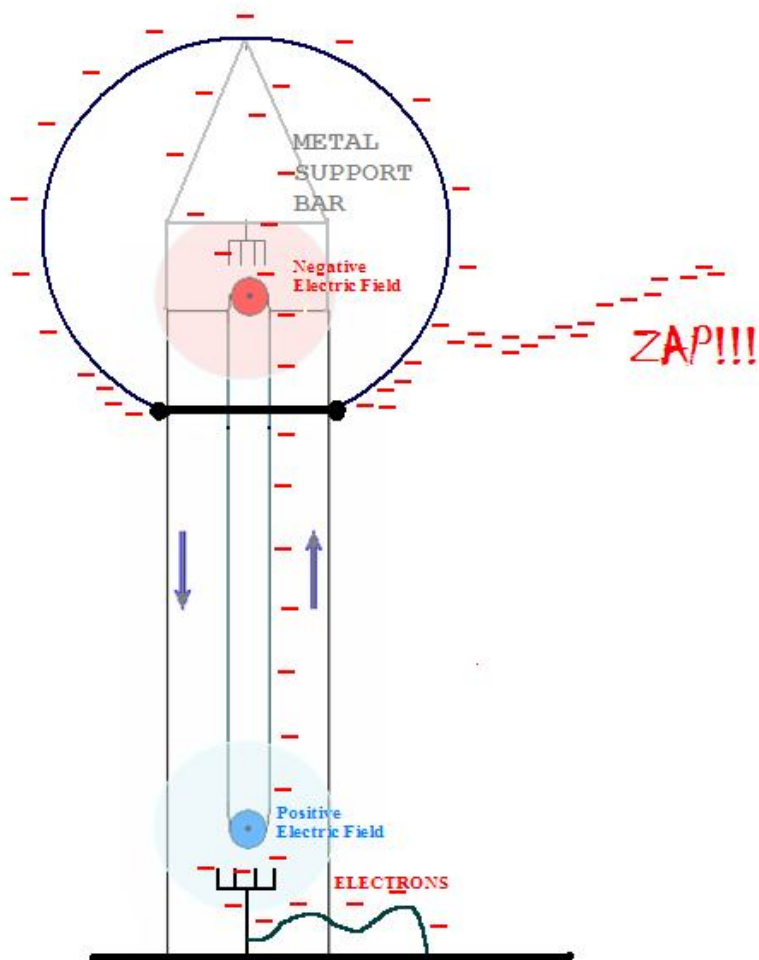
- Scissors
- Pliers for Crimping Terminals
- Razor Blade
- Screw Driver
- Drill

Materials Needed

- Gorilla Super Glue
- Nylon Fishing Line
- Sand Paper

How a VDG Works:

The VDG works by taking electrons from the bottom grounded comb and transferring them to the top comb, where they are then distributed to a dome where they are trapped and accumulated to produce a very large electric field. The heart of this charging process is dictated by two physical principles. The first principle is that opposite charges attract and like charges repel such as in magnets. The second physical principle is that many objects develop either a positive or negative charge when rubbed. This process of charging is often done on a daily basis such as when you rub your feet on the carpet and accidentally shock the cat or when you pull your clothes from the drier and feel the clinging sensation from the charge that built up on the clothes while drying. As found in the **triboelectric series**, some materials develop a stronger + or - charge than others.



With these physical principles in mind, let's now look more closely at how the VDG dome receives the charge that makes our hair stand up. When the latex belt runs across the bottom nylon roller it develops positive charge which then produces a positive electric field. The free roaming electrons on the bottom metal grounded comb begin to feel the attraction from the positive electric field, causing them to fling toward the roller. However, since insulating latex belt is between the comb and the roller, the electrons get stuck to the latex belt surface, where they are then transported to the top to be flung right back off.

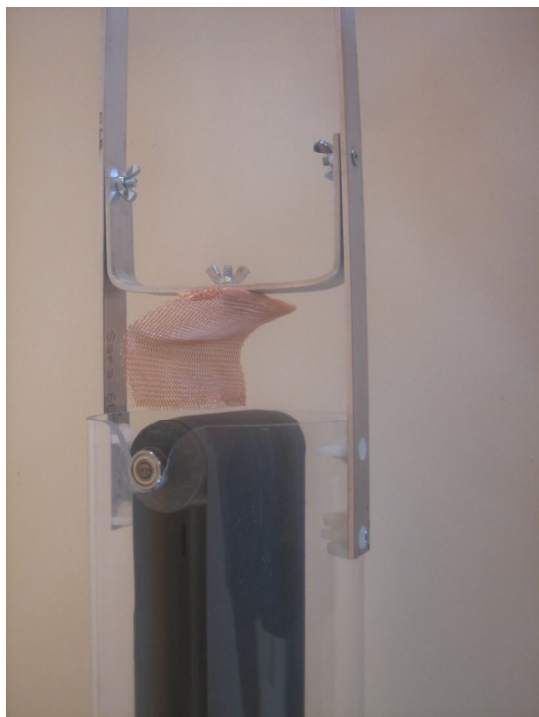
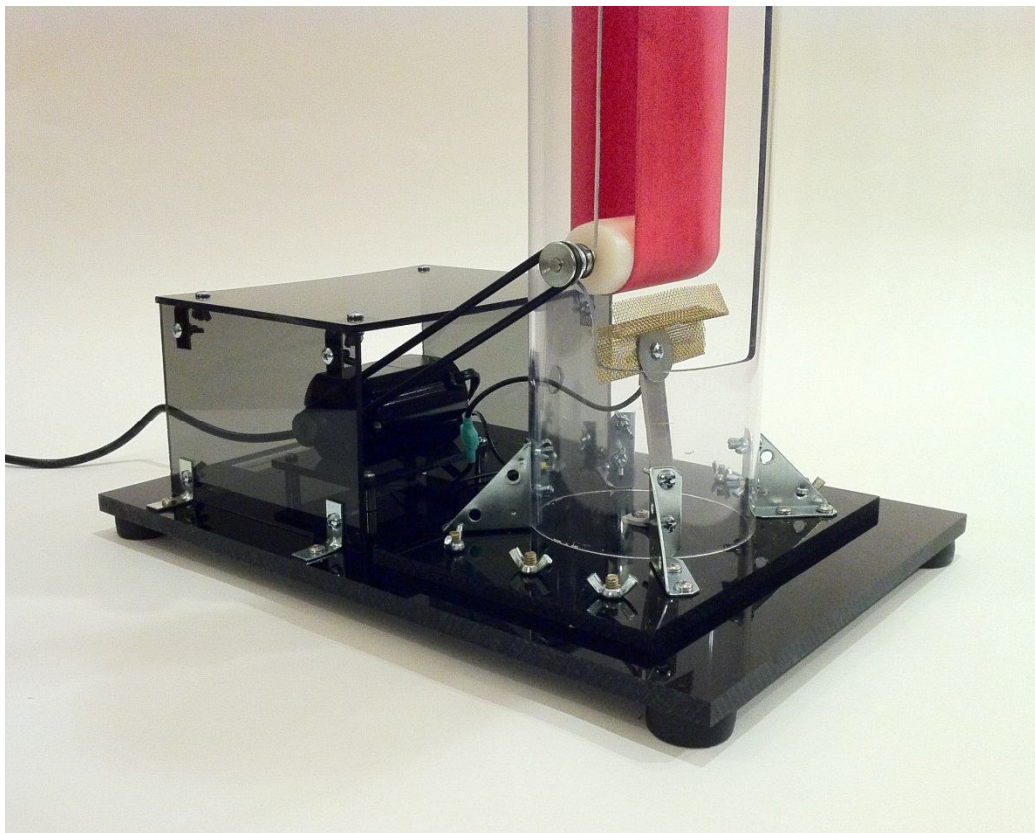
During this process the top roller develops a negative charge that emits a negative electric field. As the electrons on the latex belt begin to approach this roller, they start to feel its repulsive negative charge, where they are flung to the closest conductor they can find, which so happens to be the top comb. The electrons are then pushed through the metal support system, to the stainless steel

discharge dome where they accumulate to produce the hair standing electric field. As the belt rounds the top roller, now approaching the bottom, it will have a neutral charge due to the excess electrons expelled to the dome. If the top roller can develop a large enough negative charge, it will produce a returning positive charge belts, which in turn will be advantageous to attracting even more electrons from the bottom comb.

The dome is one of the most crucial parts of the VDG, which accounts for at least 80% the generator's final output voltage. So that a maximum voltage can be achieved, it is essential to understand conceptually how the electrons interact with the metal sphere. Once the electrons make it to the dome, they are now roaming around and cramming against each other due to their individual repulsive electric fields. Essentially they are looking for a way out, which consist of any edge or point on the surface that offers a path of least resistance. By referring to the illustration, there is a high concentration of electrons located at the discharge sphere's bottom edge because this is a region where the electrons feel the lowest resistant and will try to prematurely leak off (**leakage**), hence creating a lower voltage. To prevent this from occurring, the dome has an insulation that lines the bottom edging.

Not only will the electrons try to leak off from the bottom location, but from any protruding scratch or even dust/dirt particles. Because insulators become conductors at high voltages, mostly any material on the dome such as dust or debris could create a point of leakage. If there are no points of leakage present, the electrons will build to such great numbers that they will arc to surrounding objects or even down the acrylic tower. Just wait and you will see!

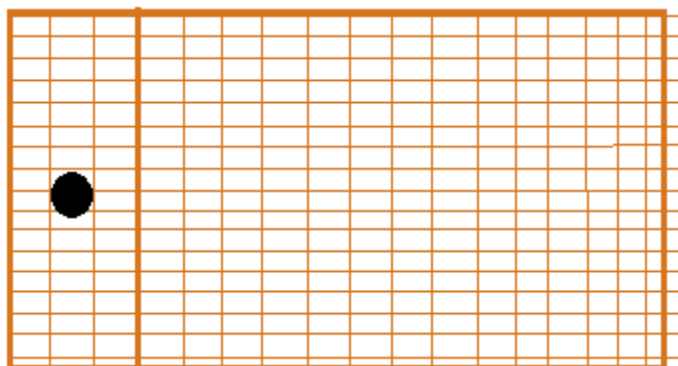
Tower Construction Illustrations



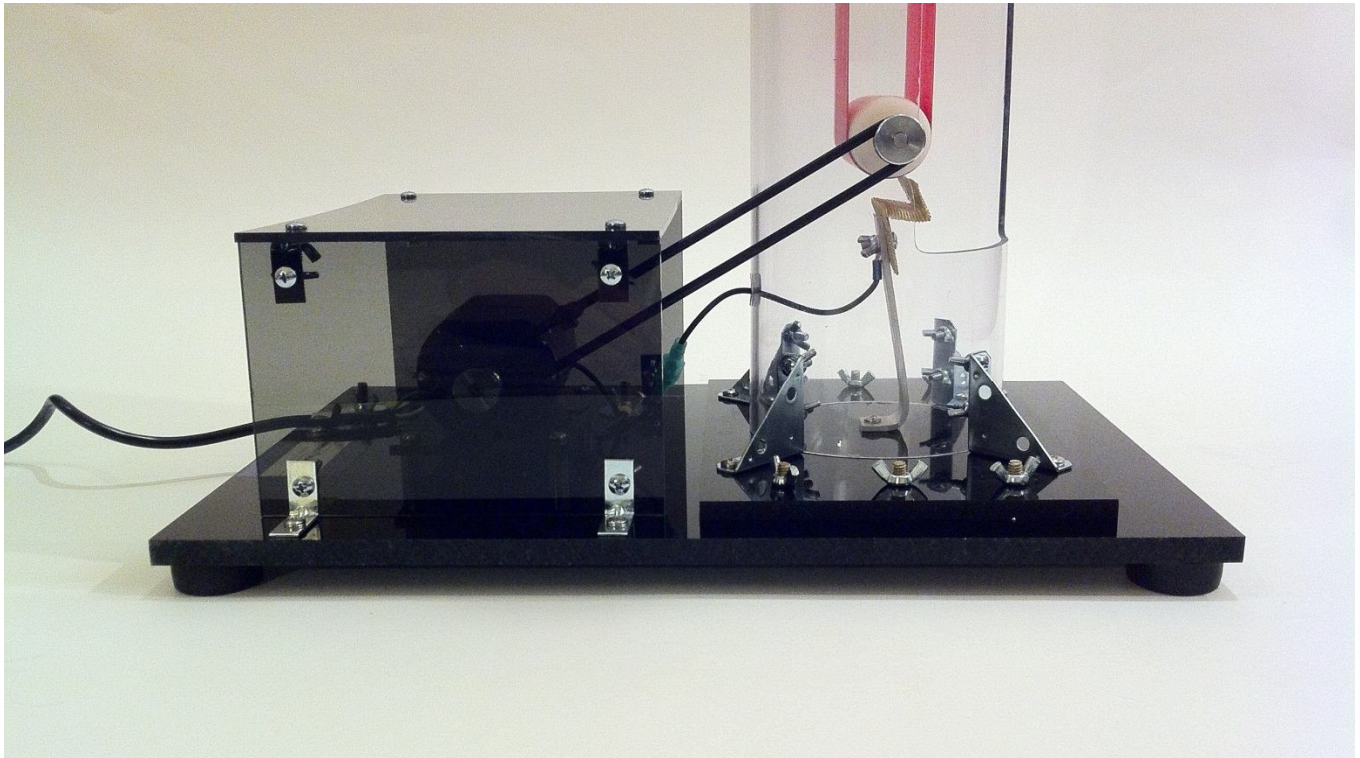
Tower and Support System

Procedure:

- 1) Obtain the main support system along with the center brace that holds the top discharge comb. Attach the center brace using the flat head 10-24 x 5/8th screws and wing nut.
- 2) To attach the brass screen to the center brace, you will need to cut the brass screen to 4 x 5 inches. Fold the screen on one side so that there is about a 1 inch overlay and then use a pair of scissors to punch a hole where the support 10-24 x 5/8 pan head machine screw will go. The screen will use the 1.25 inch fender washer and wing nut to fasten it to the brace.

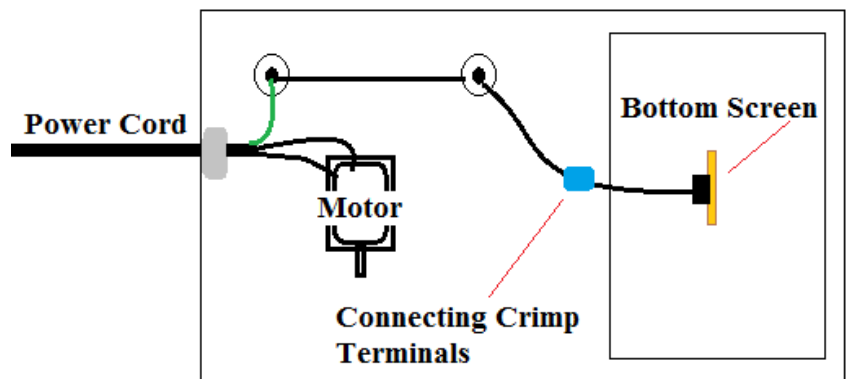


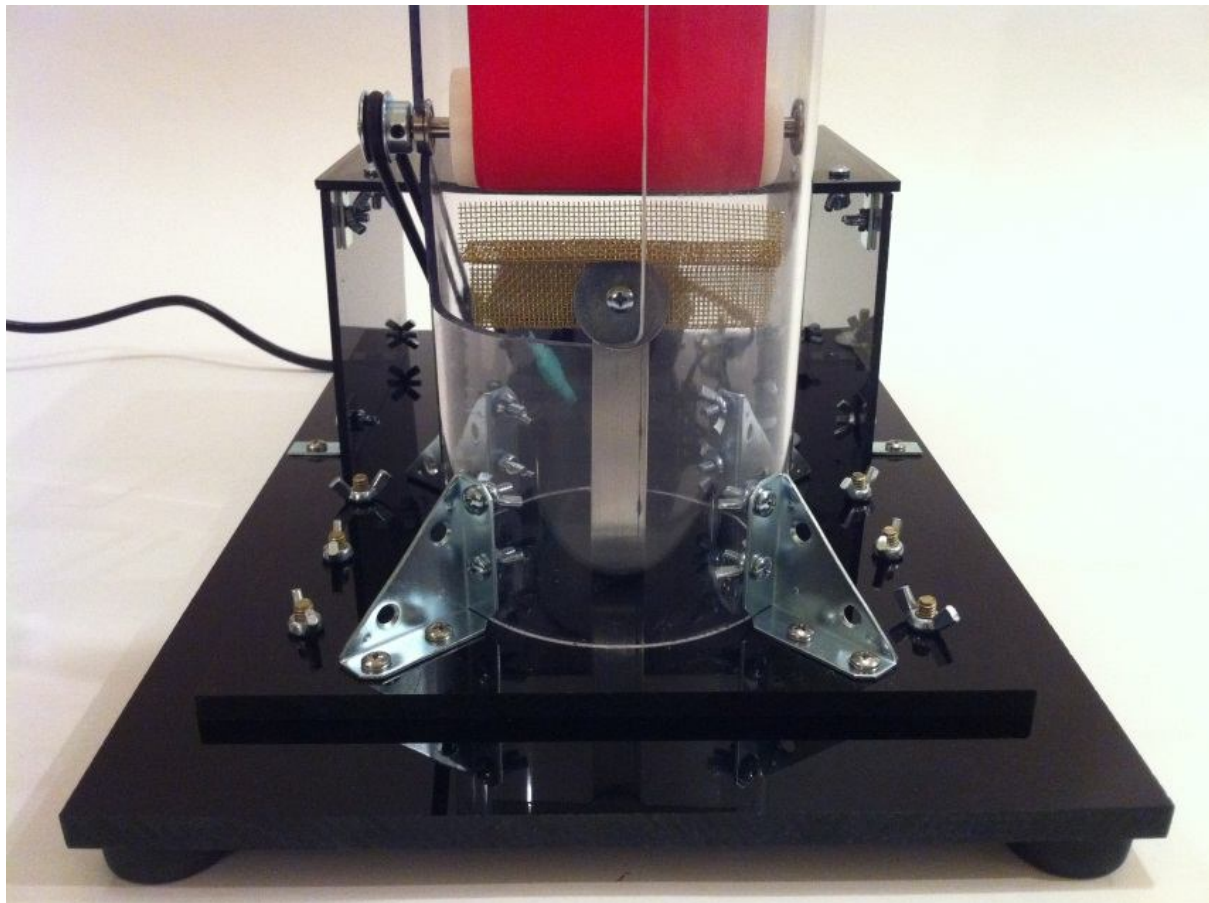
- 3) This screen will be too long so that you may create a fold in the screen to vary the distance between the screen and top roller. The distance between the top roller and screen should be about 2.5 to .5 inches.
- 4) Attach the aluminum support system to the tubing by using the 10-32 nylon screws and nylon wing nuts.
- 5) Prepare the bottom of the tubing by first attaching the corner braces to the acrylic (or CAB) using eight of the 10-24 x 5/8 pan head machine screws and wing nuts. Do not over tighten if you have the acrylic tubing. The CAB tubing (tenite butyrate) may be fastened without reserve. Please keep in mind that it is best to first place the corner braces onto the tubing verse bottom acrylic plate to avoid the difficulty of having to reach through the tubing to attach the wing nuts. Some acrylic units will have the bottom of the tubing tapped with a 10-24 screw hole, however they will still need the wing nut attached on the inside.



6) Prepare the bottom screen just as the top, however only make it 3 inches long. Attach the screen to the bottom aluminum support system using a 10-24 x 5/8 machine screw, 1.25 inch fender washer, and wing nut. On the other side of the screen will connect the grounding wire which uses the blue ring terminal. The grounding wire stemming from the bottom brass discharge screen will have a male/female crimp terminal connection. This was implemented for those traveling with the unit and need to quickly disconnect the tower from the base. Please refer to the illustration and drawings for reference.

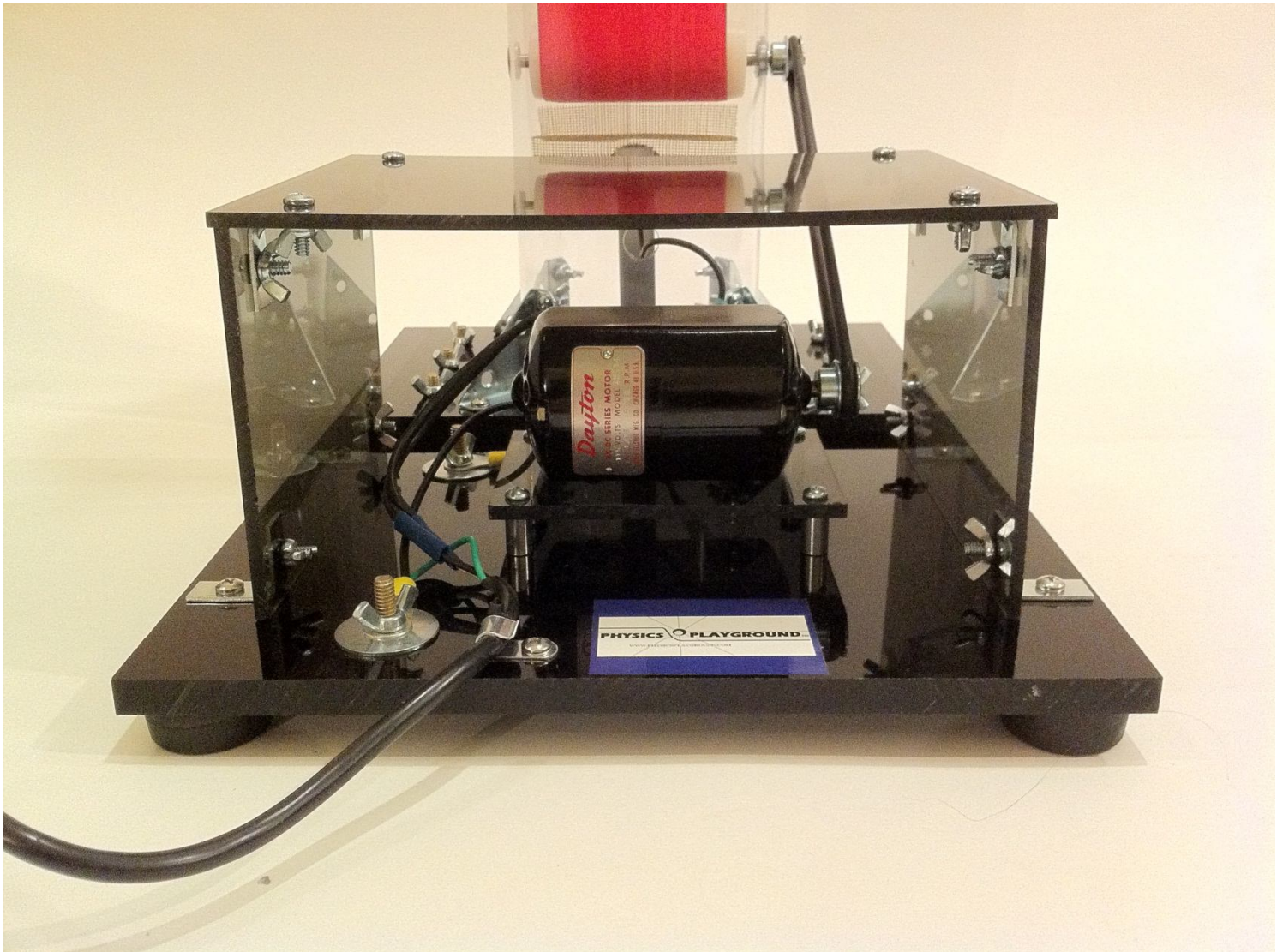
7) To fasten the bottom discharge screen support system and tubing to the small 7 x 10 x 3/8 inch acrylic base plate, use the 10-24 x 3/8 pan head machine screws that anchor into the tapped 10-24 holes.



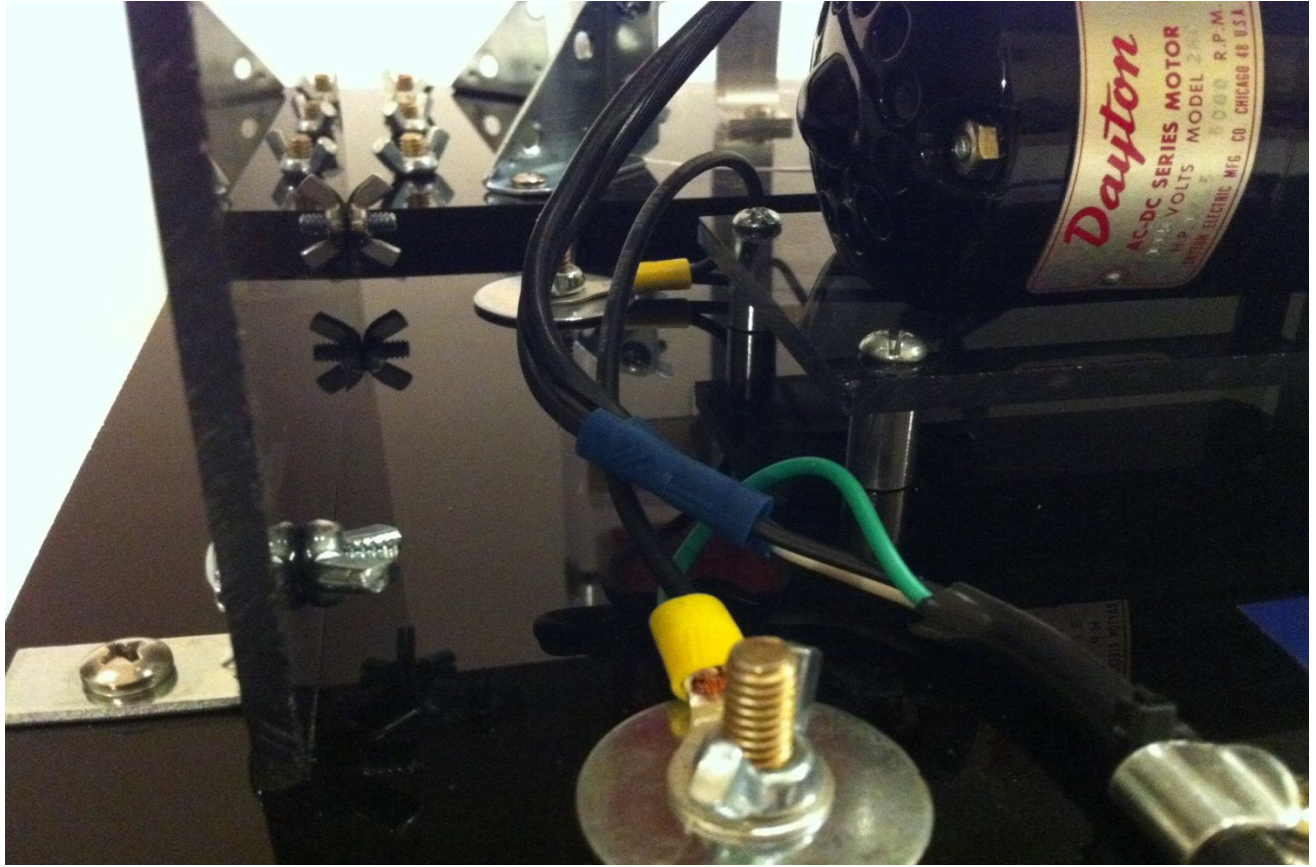


Crucial Design Notes

1. It is crucial that the aluminum support system stays on the outside of the tower otherwise electrons will leak back on to the belt, hence not allowing the system to build a maximum charge.
2. The discharge comb should not drag on the belt while running. Keep it between .25 to .5 inches away from the rollers.

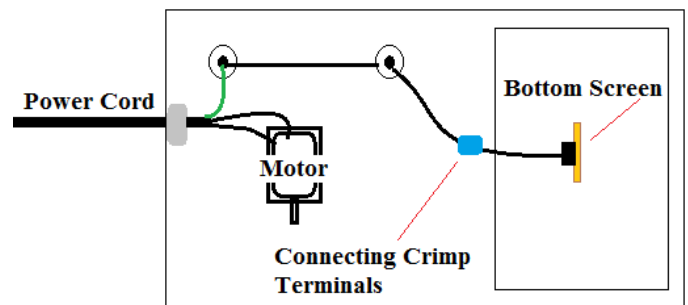


Motor, Motor Cover, & Wiring:



Procedure:

- 1) Locate the motor, power cord, blue crimp terminals, and larger yellow ring terminals.
- 2) Cut off the female end of the power cord and then strip the 4 inches of casing from the cord. Located the black and white wires which are 110V leads. Splice 3/16 of an inch from the wires. Cut the wires from the motor to 4 inches long and splice the ends and then connect them to the black and white leads from the power cord.
- 3) Next, connect the green ground wire to the first grounding bolt using the larger yellow ring terminal along with another wire that leads to the inner grounding bolt. From the inner grounding bolt will also connect the wire leading from the bottom discharge screen.



- 4) Attach the motor to the small motor base plate using 10-32 x $\frac{1}{2}$ inch machine screws and washers. Each screw will need to be spaced with about three #10 washers so that the screw does not interfere with the inner rotating parts of the motor.
- 5) To connect the motor to the main VDG base, locate the four $\frac{3}{4}$ inch aluminum spacers and four larger 10-24 x 1.25 pan head machine screws. As seen in the illustration with the motor and wiring, the machine screw will go through the small motor base plate and then through the aluminum spacers and into the tapped 10-24 holes in the acrylic.
- 6) Connect the motor cover by using the 10-24 x $\frac{5}{8}$ pan head machine screws, wing nuts, and 1 inch L-Brackets as seen in the photo below. The Motor cover will screw into the 10-24 tapped holes in the acrylic base using the 10-24 x $\frac{3}{8}$ pan head machine screws.



Rollers and Combs:



Procedure: Bear and Axles

- 1) The rollers will arrive as a solid Delrin (black) and nylon (white) roller. To assemble these rollers, place the axles, pulleys, and bearings in the order as seen in the illustration above. The pulley are only a press fit into the axle and will need either Gorilla Super glue or a two part epoxy to hold them in place
- 2) The bearings are designed for a very tighter fit. The bearings that connect to the shorter 1.25 inch axle will only need to be pressed in. This may be done by first starting them with a hammer by very gently tapping them in and then using a vice press for best results.
- 3) The bearing that slides over the larger 2 inch axle will need extra preparation. For best results, the first 1 inch of the axle should be sanded down using a sand paper and a drill as seen in the illustrations on the next page. This is done so that the bearing more easily slides over the axle. Lastly, slide the bearing onto the axle so there is $\frac{3}{4}$ of an inch left over the pulley to fit and then use Gorilla Super glue or a two part epoxy to adhere the bearing.

Preparing the Drive Axle

- 1) When sanding the longer axle it is important to NOT sand that part of the axle that fits into the roller because it will no longer hold a press fit in the roller. To sand the axle, just place it in a drill and run a piece of sand paper over the axle while spinning. Do this for only a few seconds and test the bearing on the axle.
- 2) This process may have to be repeated a few times until the bearing slides over the axle.



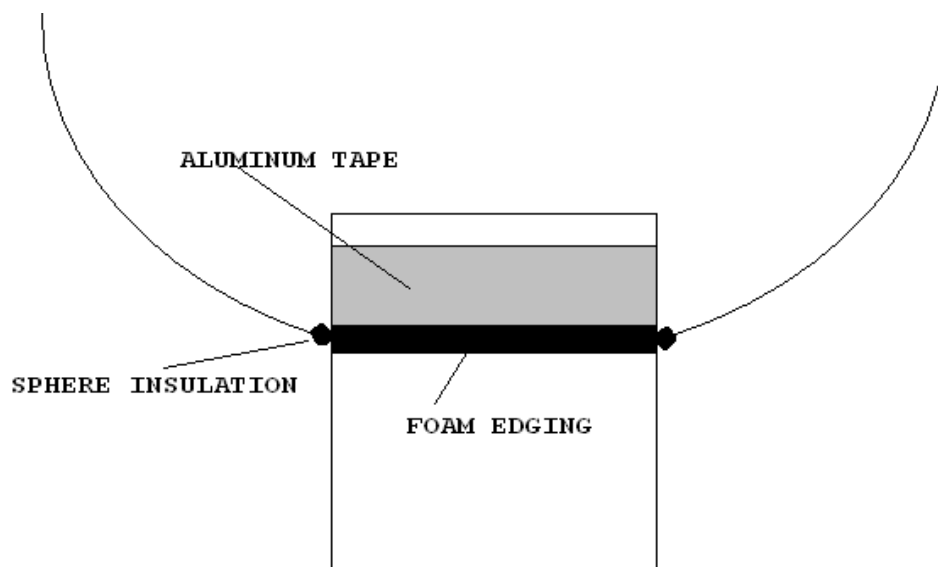
Roller Coatings:

- 1) The rollers are designed to have high friction coatings that intensively enhance the VDG's performance. The Delrin roller uses a Pliobond coating. It is common that this coating will wear off over time and may be purchased from Ace Hardware.
- 2) The nylon roller comes with 100% wool felt. Though the generator will run without it, the felt will almost double the VDG's output and will increase its efficiency on humid days. Attach the felt by first using a very light amount of super glue along with a q-tip to spread the glue. Too much glue will shut off the VDG. Next, wrap the felt with fishing string and fuse the end string with super glue. The string may also be adhered to itself by melting it. This is done by melting the string with a lighter and then pressing it into the end wrapping.



Machining the Dome:

- 1) The newer VDG sphere will come machined and will only need the insulation applied. When connecting the insulation, be sure to press it on as tight as possible so that there is no gap where the two ends meet. Should there be a gap, use a two part epoxy to cover it.
- 2) Once the insulation is attached, place the sphere on the VDG tubing with the aluminum support system already connected. With the sphere resting on the aluminum support system, place a mark on the tubing at the bottom of the sphere. This is the location where the foam edging will be placed in order to fill the gap between the insulation and the tubing.
- 3) To secure the foam edging, it is advisable to place a wrapping of electrical tape around it.
- 4) Once the edging is on, place the aluminum tape just above the edging. The aluminum tape is used to prevent leakage from the bottom of the sphere and will allow potentials to reach over 700KV. If you do not want the VDG to run at its maximum strength or are having issues with the VDG arching to the base, take off the tape to allow leakage to occur. Inducing leakage will reduce the voltage by about 100KV. The voltage may also be reduced by pulling the combs further away from the rollers.



Do you want an extra 100KV to 200KV?

Wrap electrical tape around the bottom of the dome to further insulate the edge. This will enable device to produce much larger arcs and reach 800 to 900 kv potentials when ran at full speed.

Approach with absolute caution!

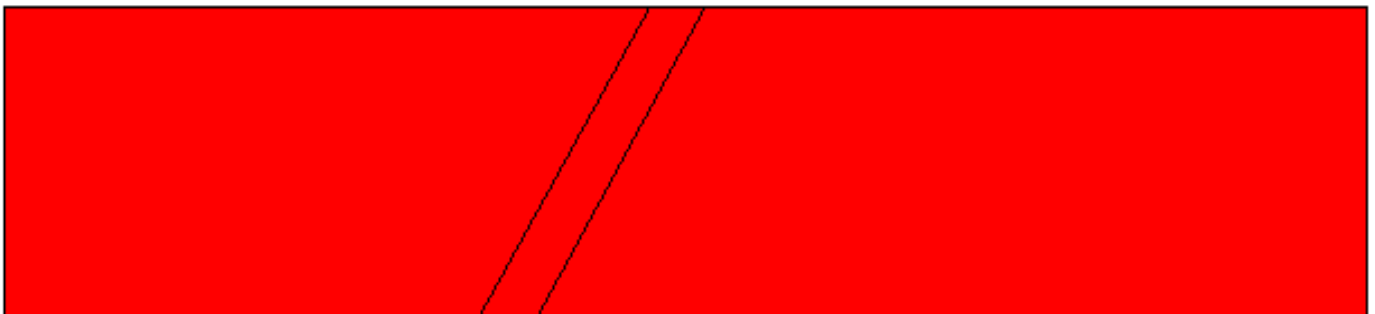
Crucial Design Notes:

- 1) Be sure to clean the inside of the dome otherwise metal shrapnel will fall to the belt and roller system and interfere with the charging process.
- 2) The black insulating strip must be placed on very tightly with no metal edging showing.
- 3) Touching the speed control while standing too close to the VDG will **destroy the speed control**. Stand at least 6 feet away while adjusting the speed.

Mending the Belt Material:

- 1) To mend the belt material, you will have to cut the ends of the 48 inch belt with a sharp pair of scissors to create a 30 to 45 degree lap joint. Next, mend the belt ends with Gorilla Super Glue only. To mend the ends, create a .375 to .5 inch lap joint and then lay a piece of paper between the joint and the belt below to prevent unnecessary adhesion.
- 2) When applying the glue, pick up on one side of the lap joint and then spread the super glue using a Q-tip. Next, press the lap joint together where glued for about 1 minutes. Do the same for the other side of the lap joint.

USE A 45 DEGREE LAP-JOINT WITH A .25 TO .5 INCH OVERLAY



ONLY USE GORILLA SUPER GLUE TO MEND

VDG Operation Instructions

VDG Assembly for Test Run:

- 1) Before placing on the belt and rollers, **rewash the belt and both rollers using dish soap**. Try to avoid getting water on the bearings. When finished, dry a paper towel.
- 2) **Warning: These belts are designed to create a very high tension system to avoid harmonics at high RPMs.** To assemble the belt and rollers, it is easiest to first place the belt on the top roller and then feed the belt material down the tube. Next, reach up with your left hand and place it through the loop of the belt and then pull down. With your right hand, insert the bottom roller and then release the belt with your left. Please note that it is important that your left hand is through the loop and not just pulling with your fingers.
- 3) Attach the drive belt from the motor to the bottom Pulley
- 4) Space the top and bottom combs from .25 to .5 inches.
- 5) Turn the generator on without the dome attached and feel the top support system for sparks. If there are no sparks, blow a hair dryer through the bottom opening until it develops a charge. This may take up to 5 minutes. Under optimal conditions, there should be a continuous stream of sparks consisting of 2 inch arcs coming from the support system when touched. A majority of the time the VDG will start right up, however if it is still lagging, rewash the belt and rollers and allow it to run for about 10 minutes. You will find the more you use the VDG, the stronger it will operate.
- 6) Gently place the dome on top of the support system and screw the nylon bolt through the top dome insertion hole.
- 7) The sparks should average about 12 inches, with max sparks at 30 inches. If you are not getting 12 inch arcs, it could be due to a variety of reasons such as high humidity levels or sharp pointed grounded objects in the vicinity that create ion jets and pull the electrons from the dome, hindering the VDG from building a charge. *Please refer to trouble shooting.*

Trouble Shooting:

- 1) Problem: Humid day or working in large crowded auditoriums. This will decrease the voltage by half. That is why they say we have good VDG weather and bad VDG weather.

Solution: Blow a hair dryer through the bottom of the VDG roller entrance hole.

- 2) Problem: Dust particles on dome that cause leakage.

Solution: Clean the dome after each hour of use. Even small dust particles will cause points of leakage. To see the points of leakage, run the VDG with the lights out and look for small blue ion jets. Brush the ion jet away and the VDG will produce rather large arcs. Be very careful while trying this technique

- 3) Problem: Oil on belt and rollers. This will shut the VDG off.

Solution: Wash the top and bottom roller with soapy water.

- 4) Problem: Belt is not dry enough after washing. This will shut the VDG off.

Solution: Blow hot air up through the bottom of the tower while running.

- 5) Problem: Pointed metal objects around the VDG will cause it leak.

Solution: The VDG cannot be around pointed objects because they will prematurely pull charge from the dome and not allow it to build to its maximum potential. Keep the VDG located in open space.

- 6) Problem: Belt begins to rub on the combs at very high speeds.

Solution: Once the belt develops a large amount of wear, it will loosen and possibly brush the combs during operation. This will indicate that it is time to change the belt. These belts are made from a latex material and will break down in UV light, therefore when finished using the VDG, take off the belt and place it in a dark location. These belts should last a very long time if stored correctly.

VDG Maintenance:

- 1) Do not allow the belt to come in contact with the combs during operation in order to maximize the belts life.
- 2) Latex will oxidize when in the presence of ozone or UV light. The ozone is inevitable due to the voltage produced, however the UV will inflict a significant amount of damage over time, therefore **always store the belt as removed and in a dark place when not in use.**
- 3) Never clean with alcohol or acetone due to sever cracking of the acrylic or CAB tubing.
- 4) The VDG belt and rollers may be cleaned with dish soap and water. Try to avoid water contact with the bearings.
- 5) All parts of the VDG charging system (dome, belt and rollers, and tower should be cleaned every 2hours of run time.

VDG Safety:

- 1) VDG's should not be used around people with heart condition or pacemakers.
- 2) Participants with nervous disorders may be very sensitive to the VDGs such that the VDG may cause heightened levels of anxiety. This is not a well-documented and support fact in the education or health care community, however there have been situations inquired about that eluded to this being a possibility.
- 3) Be careful not to make items that will act as high voltage capacitors. The current from the VDG's are safe, however when the current is allowed to be stored at such high capacitances, they can become lethal when discharged.
- 4) Larger VDGs can produce welts from prolong exposure to arcs.
- 5) Keep away from all electronics and do not use in the same circuit that is used for other electronics
- 6) Operate in well ventilated areas due to the ozone produced.
- 7) Avoid making human chains.
- 8) Keep the speed control away from VDG while in operation. Never touch the speed control while standing closer than 6 feet from the VDG.

Warranty and Replacement Parts:

Warranty: Physics Playground generators and high voltage equipment are covered under a one year warranty except for static belts and speed controls. Sign of rough use, such as dropping, over tightening hardware, and exposure to caustic chemicals will dismiss the equipment from eligibility of the warranty.

Prior to sending a replacement part, the buyer must email a photo of the damaged part to frederickgraff@hotmail.com for verification. All replacement parts will be shipped within 4 business days.

Consumable Parts: Please visit Physics playground for replacement parts. Both belt material and pre-made belts will be sold on the website. For those who wish to mend their own belts, the belt sizes are listed below.

- 400KV VDGs:
(2 in x 32 in)
- 350KV High Current VDG:
(3.5 in x 35 in)
- 500KV to 700KV High Current VDGs:
(4.5 in x 48 inch)

Warning: Van de Graaff generators are not a toy and should only be used by those familiar with high voltage devices. Physics Playground does not hold responsibly for the use or misuse of the purchased high voltage equipment. Use at your own risk.