When two different materials in close contact are separated, there is usually a transfer of free electrons from one to the other. The result is that one becomes negatively charged and the other becomes positive. While these charges may be of fairly high voltage, say 5–10,000 volts, they will dissipate over time and both materials will return to a neutral charge condition. In the operation of the Van de Graaff, we have a motor-driven belt continuously separating from the lower, wool-covered pulley. We have two dissimilar materials being pulled apart and a negative charge does indeed appear on the belt. Because the belt is a good insulator, the charge is immobile and is carried to the upper pulley. Here again we have a change of materials, but in this case the charge is transferred to the pulley instead of remaining on the belt. As more charge continues to arrive, the voltage on the surface of the upper pulley rises until the electrons are able to escape across the air gap to the electrode brush. Once they have made that jump, they are free to flow out to the surface of the dome. Remember that like charges repel one another and the locale of greatest spacing will always be the outside surface of a conductor. In time, the charge on the dome will build up to the point where electrons will begin to escape by ionizing the surrounding air or arcing to a nearby ground point. In any case, a point of equilibrium will be reached, and the dome’s voltage level will no longer increase.

N-122 DISCHARGE ELECTRODE
Let’s look again at the basic arc discharge. If a grounded discharge electrode is brought near the dome, there is a sharp, cracking arc between the two. The length of this discharge will naturally be proportional to the voltage which we are developing on the dome under the conditions as they exist at this moment. With the small 4-inch discharge electrode, on a good day, we will typically get an arc of about 4–6 inches. A crude estimate of this voltage level is about 30,000 volts per inch.

N-122L DISCHARGE ELECTRODE
If we repeat this demonstration using the large ten inch discharge electrode, we will get somewhat similar results, except that the arc will be shorter, but more intense. The larger dome presents a less concentrated target for the arc and a higher voltage gradient is required across the air gap. Notice that there is obvious movement of the two domes, indicating that there are some real mechanical forces at work. Before the discharge, the domes are attracted by induction, but this force is suddenly released by the arc. We will talk more about these forces a little bit later.

N-127 POINT TERMINAL
Let’s go to the other extreme and approach the dome with a small object, say a single finger. Notice that it’s possible to get very close before any arcing occurs. With a penknife pointed at the dome, the arc is only a fraction of an inch long. Yet if the small discharge electrode is again brought near, you can see that conditions really haven’t changed. The explanation is simply that the sharp point provides a path of relatively low resistance for the charge to escape from the dome. In fact, the charge escapes so fast that the voltage level of the dome is drastically reduced and only very short arcs are possible. When this demonstration is done in the dark, you will see a faint glow around the point. This is called corona discharge. It is the continuous excitation and ionization of the air that causes the emission of light.

Placing a point terminal on the dome using its suction cup will create a very high voltage stress point in the atmosphere. This will result in ionization of the air in the vicinity. These negatively charged particles are immediately repulsed and there is a very noticeable wind. Holding your hand nearby
clearly indicates the presence of a breeze. This can better be shown with a piece of ordinary facial tissue. Separate the usual two plies to get a very lightweight indicator. To be sure the there are no skeptics, remove the point terminal and again bring the tissue near the dome. It is obviously being attracted, not repulsed. The presence of the wind can also effectively be demonstrated with an ordinary child's pinwheel.

N-124 ELECTRIC WHIRL
A near cousin to the point terminal would be the Electric Whirl. This is a device with three or more arms balanced on a central pivot which allows it to rotate with ease. When brought near the dome of an operating machine, the arms will immediately begin to rotate. The electrons first escape from the dome to the arms. The high voltage concentration at the points ionizes air particles, which are then repelled. The reaction to this repelling force causes the arms to rotate. Even if you spin the arms in the "wrong" direction, they will come to a stop, and start back up with the correct rotation.

N-125 ELECTRIC PLUME
The Electric Plume is simply a collection of ribbons attached to a suction cup. When it is mounted on top of the dome, the ribbons will each become charged. Here again, the forces of repulsion between like charges comes into play. Each ribbon becomes negatively charged and tries to get as far as possible from the dome and from each of the other ribbons.

N-141 RACING BALL
The Racing Ball is another way to show the force of repulsion between like charges. With this device we have a plastic ball sitting in a level dish which is connected to ground. Above the ball is a flat plate which is brought close to the dome or may even be connected to the dome with a wire. The upper plate becomes negatively charged, and some of this charge will migrate to the top of the ball. A repulsion force is then created between the ball and the upper plate which can only result in the ball rotating. When the ball is first influenced by the charge, it may move in almost any direction. After a few moments it will usually be helped by the rising sidewall of the dish to find a continuing path around the dish. When setting up this demonstration it is important to have the dish quite level. The forces involved are not all that great, the ball is fairly large and it isn't going to roll uphill. (Note: This demonstration was omitted from the DVD because of its similarity to some of the other included demonstrations in terms of the principles involved. Also, it did not really introduce any new material.)

N-142 HOLLOW CYLINDER
This is called a Hollow Cylinder because that's just what it is. On the topside we have two pitchballs tied by light thread, and on the inside we have two more pitchballs suspended in the center of the cylinder. The best way to demonstrate this device is to charge it indirectly from the dome of the generator. The small discharge electrode or the proof plane will work very nicely. Touch the Van de Graaff dome with the smaller ball and then transfer the charge by touching the ball on top of the hollow cylinder. What we can observe here is that the pitchballs on top become charged and are repulsed from the cylinder, just as you would expect. But note that the balls inside the cylinder are completely unaffected. This is because the charge on the cylinder resides on the outside surface only. It will not go onto the inside of this conductive surface because of the forces of repulsion. Let's go back for a moment and comment on why it's best to charge the hollow cylinder in an indirect manner. When the Van de Graaff is working well, there is usually enough electric wind to upset proper charging. Both the pitchballs and the cylinder will become charged by the ionic wind before you have a chance to use the charge transfer device. If you want to charge directly from the generator, first turn the machine off. The voltage level will naturally subside but there will still be enough charge for this demonstration.

N-139 LIGHTNING PLATE
The Lightning Plate makes for a fun demonstration, but at the same time, clearly shows some interesting aspects of charge behavior. The top of the plate is connected to the high voltage of the dome and the other end is connected to ground. The plate is simply a pattern of flat metal conductors on an insulating surface. When the Van de Graaff is operating, the discharge path is quite visible at the ends of each of the conducting sections. First, note that the discharge path is not a random jumping from one section to another, but clearly follows the shortest path to ground. Second, note that the discharges are quite uniform in intensity even though some are longer than others. The explanation for this type of discharge pattern is that the dome will charge the first metal section until it has enough potential to jump to the next one. The process continues down through the pattern until the charge reaches ground.
**N-132 VOLTA’S HAIL STORM**
Volta’s Hail Storm is another fun device that also shows some important aspects of electrostatic charges. The unit is a hollow tube of clear plastic with metal top and bottom plates. For the first demonstration we will remove the lid and load the unit with about a tablespoonful of vermiculite. Now bring the small ball on the top near the generator and the action starts. The small particles jump up and fall back in a wild and vigorous manner. What is happening is that the particles are first attracted by induction to the upper plate. As soon as they touch, however, they acquire a negative charge and are then violently repelled toward the bottom plate. If the lower plate is at ground potential, the negative charge will be lost and the cycle will repeat.

Another demonstration with Volta’s Hail Storm is to show the precipitation of smoke. For this, we must remove the vermiculite and in its place put a small piece of ordinary wire screening. Now the tube is filled with smoke and the top replaced. Quickly bring the unit close to the dome and the smoke disappears. It has been attracted to one of the electrodes where its charged is neutralized and the particles stick. This, of course, is the principle on which industrial smokestack precipitators operate.

**N-146 NEON WAND**
Another demonstration that commands a lot of attention is the lighting of a Neon Wand or a fluorescent lamp by allowing the current (a few microamps) to flow through a person’s body to ground. The neon wand works better because it gives off more light for the available power. It is a glass tube, filled with neon, which has metal electrodes at either end. These electrodes facilitate the passage of current. Hold the tube by the handle end and then bring the other end close to the generator. The voltage across the gas in the tube excites the neon and light is emitted. When using the wand, always point one of the electrodes directly at the dome. Do not bring the middle of the tube toward the dome as the tunneling action of the electrons will cause very tiny leaks through the glass wall, allowing air to enter. The unit will then no longer work. A small fluorescent tube will also work, but the light output is harder to see unless the room is darkened.

When using either the Neon Wand or the fluorescent tube, better performance is obtained if the person holds a grounded bare wire in their hand. This will reduce the resistance path and increase the light output. As a matter of fact, almost all of these demonstrations will come off better if the person is well grounded.

To increase the light output of the Neon Wand, place a small piece of foam on the bare electrode wires, something of the size of a typical packing peanut. This will insulate the wand from drawing a continuous current and allow the generator to build to a higher voltage before it arcs to the electrodes. Now, instead of a continuous low current, we get rapidly repeated discharges of much greater momentary current amplitude and hence, more light.

**N-144 FLYING BALL AND SILVER SNAKE**
Now that we have just made a pronouncement about the importance of grounding, let’s talk about a demonstration in which it is quite unnecessary. We are going to look at two items which together can be used to show a great deal about electrostatics. The first of these is the Silver Snake. It is an insulating plastic rod from which hangs a length of metalized ribbon. When the ribbon is brought near the generator, it is attracted by induction, but then repulsed as soon as it touches the dome. After a few moments, the charge will leak off into the air, and the ribbon will again strike at the dome. There may be wide variations in this action, depending on the operating voltage level of the dome and the relative humidity. If the humidity is unusually low, the charge may not leak off very fast.

The Flying Ball is just about what the name indicates. It is a lightweight metalized ball on the end of a thread hanging from the end of an insulating rod. The first step in this demonstration is to carefully and slowly bring the ball near the dome. Hold the ball with your hand to keep it from being charged by the electric wind from the generator. This must be done slowly so as to clearly show the attraction by induction that will take place when the ball is released three or four inches away. As soon as the ball touches the dome, as you would expect, it is sharply repelled. The ball shape tends to hold the charge longer than any other geometric shape, and the ball will now “float” around the dome but always at a respectful distance. The forces of repulsion are clearly present all around the dome. And the higher the generator voltage, the better the demonstration. Naturally, the voltage charge on the ball will eventually dissipate and the cycle will repeat.
STAND UP HAIR
The last demonstration that we will attempt is the most requested of all: that of making a person’s hair stand up. This is fun for the class, but not necessarily an easy act to pull off. If the entire person can be raised to a high enough potential, then the hair will act in much the same way as the electric plume did earlier. Easy to say, not so easy to do.

The first step is to insulate the person from ground by having them stand on something sturdy, such as a plastic milk delivery crate. Be sure it is the real thing and not some cheap, lightweight imitation. Second, pick your volunteer carefully, making sure they have no medical condition (such as a pace maker), that would possibly pose a problem. Obviously, the smaller the person, the less surface area there will be for charge leakage back to the atmosphere. All metal items such as rings, watches and pens should be removed. These will act like the discharge points, as we have shown before. The forces of repulsion are modest, so pick a candidate with clean, dry, straight and relatively short hair of perhaps three or four inches in length. Long and curly hair will simply not disentangle and the demonstration will be a disappointment. On a good, dry day, don’t be afraid to try a volunteer with somewhat longer straight hair. If it’s a go, it makes for a very good show. Blond hair is usually finer than brunette and therefore is often a better choice.

Have the subject place their hand on the dome with clear instructions to keep it there at all times until the demonstration is over. After the machine has been started, it will begin to build up charge and will reach its maximum level in a minute or so. Throughout all these demonstrations you have seen that the generator by itself will come up to potential very quickly, typically in fifteen seconds or less. It is wishful thinking to believe that, if you let it run for five or ten minutes, something spectacular will happen. You should see some hair activity almost immediately.

When presenting this demonstration, have your volunteer stand on the side of the machine opposite from the controls. This allows you to reach the On-Off switch without getting physically close to the volunteer, as this might initiate an arc discharge from them to you. After turning the machine to the “off” position, you can easily drain the charge from the machine and the person by pointing your open penknife or other sharp object at the dome.

It is our hope that this DVD will help you in using the Van de Graaff generator and some of the accessories that are available. We are always pleased to hear from teachers who may have comments or suggestions. If you know of a new demonstration, or a way to improve upon those we’ve included here, and would like to share it with us or your colleagues, please write or call and ask for our manager of school product engineering. Or, you can visit our website at www.winsco.com and use the “Contact Us” page.
Electric Current

Electric current is the rate of charge flow past a given point in an electric circuit, measured in Coulombs/second which is named Amperes. In most DC electric circuits, it can be assumed that the resistance to current flow is a constant so that the current in the circuit is related to voltage and resistance by Ohm's law. The standard abbreviations for the units are 1 A = 1 C/s.

Microscopic view of electric current
Measurement with ammeter
Conventional electric current direction

Electric Charge

The unit of electric charge is the Coulomb (abbreviated C). Ordinary matter is made up of atoms which have positively charged nuclei and negatively charged electrons surrounding them. Charge is quantized as a multiple of the electron or proton charge:

- Proton charge: \( e = 1.602 \times 10^{-19} \text{ coulombs} \)
- Electron charge: \( -e = -1.602 \times 10^{-19} \text{ coulombs} \)
The influence of charges is characterized in terms of the forces between them (Coulomb's law) and the electric field and voltage produced by them. One Coulomb of charge is the charge which would flow through a 120 watt lightbulb (120 volts AC) in one second. Two charges of one Coulomb each separated by a meter would repel each other with a force of about a million tons!

The rate of flow of electric charge is called electric current and is measured in Amperes.

In introducing one of the fundamental properties of matter, it is perhaps appropriate to point out that we use simplified sketches and constructs to introduce concepts, and there is inevitably much more to the story. No significance should be attached to the circles representing the proton and electron, in the sense of implying a relative size, or even that they are hard sphere objects, although that's a useful first construct. The most important opening idea, electrically, is that they have a property called "charge" which is the same size, but opposite in polarity for the proton and electron. The proton has 1836 times the mass of the electron, but exactly the same size charge, only positive rather than negative. Even the terms "positive" and "negative" are arbitrary, but well-entrenched historical labels. The essential implication of that is that the proton and electron will strongly attract each other, the historical archetype of the cliche "opposites attract". Two protons or two electrons would strongly repel each other. Once you have established those basic ideas about electricity, "like charges repel and unlike charges attract", then you have the foundation for electricity and can build from there.

From the precise electrical neutrality of bulk matter as well as from detailed microscopic experiments, we know that the proton and electron have the same magnitude of charge. All charges observed in nature are multiples of these fundamental charges. Although the standard model of the proton depicts it as being made up of fractionally charged particles called quarks, those fractional charges are not observed in isolation -- always in combinations which produce +/- the electron charge.

An isolated single charge can be called an "electric monopole". Equal positive and negative charges placed close to each other constitute an electric dipole. Two oppositely directed dipoles close to each other are called an electric quadrupole. You can continue this process to any number of poles, but dipoles and quadrupoles are mentioned here because they find significant application in physical phenomena.

One of the fundamental symmetries of nature is the conservation of electric charge. No known physical process produces a net change in electric charge.
## Conventional Electric Current

Although it is electrons which are the mobile charge carriers which are responsible for electric current in conductors such as wires, it has long been the convention to take the direction of electric current as if it were the positive charges which are moving. Some texts reverse this convention and take electric current direction as the direction the electrons move, an obviously more physically realistic direction, but the vast majority of references use the conventional current direction and that convention will be followed in most of this material. In common applications such as determining the direction of force on a current carrying wire, treating current as positive charge motion or negative charge motion gives identical results. Besides the advantage of agreeing in direction with most texts, the conventional current direction is the direction from high voltage to low voltage, high energy to low energy, and thus has some appeal in its parallel to the flow of water from high pressure to low (see water analogy).

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Almost all electric equipment these days comes with a three wire line cord and plug. Your model N-100V Van de Graaff Generator is no exception. One of those three wires has green insulation (or green with yellow stripe) and the plug connects your machine to the building ground system. Inside the cabinet, the green wire is connected to the sheet metal on its own ground screw. This assures that the cabinet will always be at ground potential.

When the transport belt is turning, it pulls electrons away from the wool on the lower pulley. Over time, this pulley will, of course, become positively charged when there are no more electrons available for the belt. To sustain the belt current, there is an electrode brush, connected to ground, that is positioned to provide a current flow from ground to the pulley. With the wool re-supplied with electrons from ground, the charging process can continue.

There is a binding post mounted on the top of the cabinet that is used for grounding of demonstration accessories. Some of these accessories absolutely require grounding for proper operation, and it is up to the the user to read the product instructions to determine whether grounding is required for a particular accessory demonstration. For instance, if the N-122 Discharge Electrode is not grounded, the discharge arc will happily pass through whoever is holding the handle and find its way to ground through the soles of their shoes. And there are other accessories, such as the N-125 Electric Whirl, that do not require grounding. Be sure to read the instructions for your accessories so as to avoid any shocking surprises.

When your Van de Graaff Generator is operating, the dome voltage rises to a level where the leakage into the atmosphere is equal to the incoming belt charge. When the machine operator is nearby, the leakage will in a short time provide a significant personal charge. Now, when that person reaches for the on-off switch, there will be an arc discharge from the person to ground. If the operator holds a wire that is connected to ground, the personal charge will be drained away as fast as it arrives. It’s important to remember that holding the wire only deflects charge acquired through the air; you can still receive a direct discharge from the dome if you get too close.
MY MOTOR IS RUNNING OH SO SLOWLY...
MODEL N-100V VAN DE GRAAFF GENERATOR

It’s January, maybe February, it’s a cold winter, the furnace is going and it’s the right time to teach electrostatics. But it only lasts for a week or two and then that trusty Van de Graaff Generator goes back on the closet shelf or into some storeroom. With only a few hours of running time each year, these machines will last many, many years. We’ve had lots of calls from schools with machines that were built in the ’70s and ’80s.

A long happy life is a wonderful thing, but age does not treat all parts of your machine equally. The sheet metal, spun aluminum, and plastic column survive with little or no change. Ahh, but the oil in motor bearings will dry out and, without that slippery help, the motor will struggle to overcome the added friction.

What to do? Why, of course, oil the motor. Here’s how:

1. Remove six cabinet screws; two down low in the front, two down low in the back and two on top of the cabinet near the handles. Lift the upper part clear of the bottom and set the bottom aside.

2. Tilt the unit and release the belt from the pulley on the motor shaft. Return to upright position.

3. Locate the two screws that hold the motor to the cabinet. Loosen them. Now, keeping one hand holding the motor, remove these two screws.

4. Keep holding the motor while you position the unit horizontally.

5. Turn the motor about ninety degrees and you will see two oil holes, one at either end of the motor.

6. Using a needle oiler from your local hardware store, put three or four drops of oil in each hole.

7. Reassemble the motor to the cabinet, being extremely careful to put the long motor mounting screw through the collar that holds the column, and the short one through the sheet metal of the cabinet. IF YOU CARELESSLY PUT THE LONG SCREW THROUGH THE SHEET METAL OF THE CABINET, IT WILL PENETRATE THE STATOR WINDINGS AND THE MOTOR WILL BE RUINED.

8. Run the motor for a few minutes without the belt to verify that performance is indeed better. Put the belt back over the motor pulley and reattach the cabinet bottom.

9. You’re done!
IT’S TIME TO PUT IT AWAY...
MODEL N-100V VAN DE GRAAFF GENERATOR

Fun with the pie plates and the packing peanuts is finished. The hair standing on end and playing with the Electric Whirl are now done and over. It’s time to put your Van de Graaff Generator away for another year. Will it go on some closet shelf or into a crowded storeroom? In either case, it may have to survive a long hot summer.

Every year we have pleading phone calls wanting to know how to clean up the mess of a melted latex belt that is now lovingly adhered to the upper pulley and, in some places, to the main column. Perhaps you are a new teacher and the innocent victim of the teacher that left last year. We do the best we can to suggest cleaning methods and materials, but it doesn’t have to be this way. There is a simple, sensible routine to prepare your machine for perhaps ten or eleven months of storage.

First, you must understand that the latex belt is made from a natural rubber material, and like all products that come from Mother Nature, are subject to deterioration over time. Drying, rotting, melting, oxidizing, call it what you will, that belt will be absolutely useless next year if left in place. SO BEGIN BY REMOVING THE BELT. (If you have forgotten the routine, download Product Note PN—104). If the belt still has good elasticity and you want to try to save it for next year, put it in a locking-type plastic bag and store it in the refrigerator. Although it may possibly be up to the job for the following year, we strongly suggest that you purchase a spare a week or two before game time just to be on the safe side. You can easily do this directly from our website “Replacement Parts” page (www.winsco.com).

Re-assemble the cabinet and dome parts that were involved in removing the belt and your machine is ready for the long sleep. Store it in the original shipping carton packed into its cushioning pillows if still available. Turn the box upside down and insert the machine dome first while holding the cabinet base. Be sure to carefully tape the carton closed so that bad things don’t happen when you turn the box right side up.

Next year, be sure to let the stored belt warm up to room temperature before taking it out of the bag so as to avoid unwelcome moisture condensation on the cold surface. To prepare your belt for use, put it in a baggy with a little talcum powder. Cover it completely, then remove the belt and wipe away all the powder with a dry paper towel. The purpose of the talcum is to act as a blotting or drying agent, but after its work is done, get rid of it.

Before re-installing the belt, it’s a good idea to blow dry the wool on the lower pulley that is on the motor shaft. Use an ordinary hair dryer and let it run for 15—20 minutes on LOW HEAT. It takes time to drive out all the moisture that may have been absorbed by the wool during the off season, so be sure you let it run the full recommended time. This is best done by laying the machine on its side and running the motor at slow to moderate speed. Please be sure there are no curious fingers around that might touch electric connections.

And now let’s get back to that clean-up job that was surely caused by someone else. Denatured alcohol is the solvent of choice to loosen the sticky stuff. It may be necessary to remove the column from the cast aluminum collar. Loosen only the three horizontal screws — do not loosen any others. When putting the column back be sure to get the upper pulley parallel to the motor pulley. After the belt has been re-installed, start the motor at low speed to check on the tracking at the upper pulley. Rotating the column slightly will have a very noticeable effect on tracking. You must, of course, adjust the rubber bushings of the upper pulley to be sure it is horizontal.
IT’S TIME TO PUT IT AWAY...
MODEL N-100V VAN DE GRAAFF GENERATOR

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REPLACING THE TRANSPORT BELT
MODEL N-100V VAN DE GRAAFF GENERATOR

Following is the suggested procedure for installing a new belt (RP-601) on the WINSCO model N-100V Van de Graaff Generator.

Be sure your hands are clean and dry before proceeding.

1. Unplug the line cord from the electrical outlet.
   
   CAUTION: Do not proceed until this is done.

2. Carefully remove the top half of the dome and set it aside.

3. Remove the six cabinet screws from the front and back sides and the top of the base. There are two screws down low in the front, two more down low in the back, and two on top near the handles. Do not disturb any other screws.

4. Lift the upper part of the machine clear of the bottom and lay it down in a horizontal position. If there is an old belt still installed, slip it off the motor pulley. Stand the machine upright, remove the upper pulley from the top of the column and discard the old belt.

5. Hang the new belt over the upper pulley, hang the “pull down” ribbon in the bottom loop of the belt, and then re-insert the pulley assembly back into the slots at the top of the column, allowing the belt to hang down inside the column.

6. Carefully tilt the machine at about 45 degrees, grab the “pull down ribbon” and slip the new belt over the motor pulley.

7. Stand the machine vertically again and reconnect the line cord to a 115 volt 60 Hz electrical outlet. Start the machine at slow speed and check to see that the belt is tracking correctly (in the center) on the upper pulley. If it is not tracking correctly, press down on one end or the other of the axle to force the upper pulley into a more horizontal alignment.

8. After you have the belt tracking well at low speed, increase the speed and repeat the alignment procedure until you can operate successfully at full speed.

9. Unplug the line cord from the electrical outlet.
   
   Caution: Do not start re-assembly until this is done.

10. During the belt installation process, the brush electrodes will have been moved. They should now be re-positioned, both upper and lower, with the points of the screen wires perpendicular to the belt and approximately 3/16” away from the belt — not any closer.

11. Re-assemble the cabinet and the upper half of the dome. Clean the outside surface of the dome with alcohol or other non-abrasive cleaner followed by quick polish with an aerosol dusting preparation.

Video = http://www.winsco.com/technical/BeltReplacementTutorial.htm
UNPACKING AND INSPECTION
After unpacking the unit, immediately inspect for damage that may have occurred during transit. If any damage is noted, file a claim at once with the carrier or call the dealer from whom the unit was purchased. Save all of the packing materials so that the carrier’s claim representative can inspect them. Be sure to retain the shipping carton, the inside pillows and the corner braces. These will be of great help in properly storing the machine or when it must be transported. Always load and unload the unit from the bottom of the carton, using the handles on the cabinet base. Never lift the machine by the column or the dome.

DESCRIPTION OF EQUIPMENT
The WINSCO model N-100V Electrostatic Generator is designed to attain potentials up to 350,000 volts or more under favorable operating conditions. Potentials of 250,000 volts are perhaps more usual and provide more than enough voltage for forceful demonstrations. All units are shipped completely assembled, ready to operate.

The Van de Graaff Generator consists essentially of a motor-driven belt that runs between pulleys, one on the motor shaft and the other inside the dome at the top of the column. The variable speed motor is controlled by a rheostat whose knob is on the front panel.

When the Van de Graaff is new, it is normal for the motor to not start turning until the rheostat is almost at full speed. This is because the bearings in the motor and the upper pulley are still relatively tight. Over time those bearings will loosen up and the unit will start more easily.

FIRST USE
As received, your Van de Graaff is ready for use. In a very small number of instances, the Generator may not initially perform to your expectations. This will almost always be the result of its most recent temperature cycling experience. If the unit is unpacked in a nice warm building after a number of hours in a cold delivery truck, there will be immediate moisture condensation on the belt and pulleys and no or very little charge may result.

If, for any reason, your new Van de Graaff fails to perform, DO NOT CALL THE DEALER, but instead send an email to info@winsco.com. Include your name, phone number and the best time to call. A technical representative will contact you with help to get back up and running.

MAINTENANCE
Keep the dome and column free of dust and fingerprints. Clean with a soft cloth and an aerosol dusting polish. If dust and grime are allowed to accumulate, they present thousands of little discharge points on the surface of the dome. They can easily reduce the available voltage by 50%.

The latex transport belt is slowly attacked by the oxygen in the atmosphere, just as is an ordinary rubber band. The ozone created during operation is even more damaging, and so the belt will need to be replaced from time to time. We suggest that you have one belt on the machine and one spare.

Replacement belts are always readily available and may be purchased from your regular dealer or directly from our website at www.winsco.com. Select “Replacement Parts” from the main menu on the home page. Our buying service is through PayPal and accepts most credit cards.

Additionally, there are some special articles that you may find useful when working with your WINSCO Van de Graaff. For downloadable PDF files, please visit www.winsco.com, and look for them under the tab “Product Notes” in the main menu on the Home page.
WARNING!
The demonstrations described in the following instructions may involve hazards arising from careless handling or incorrect procedures. This equipment should be used only under the supervision of a qualified, certified science teacher.

SUGGESTED DEMONSTRATIONS
The descriptions that follow are intended as an overview of a variety of demonstrations and include a brief description of each. More extensive guidance can be found in the instruction sheets for each specific product. Please visit www.winsco.com; see “Product Instructions” in main menu.

1. THE DISRUPTIVE ARC
One of the more attention-getting demonstrations using the Van de Graaff Generator is the arc discharge. Bring a round object, such as the N-122 Discharge Electrode, within 3 or 4 inches of the dome. Be sure you have properly grounded the unit to the binding post on the top of the generator cabinet. If the generator is operating up to voltage, there will be a sharp crack and a bright bluish-white arc as it jumps from the dome to the smaller electrode. With a discharge electrode of this size, about 4 inches in diameter, you can estimate the voltage on the dome at approximately 50,000 volts per inch of the maximum arc length. With a smaller diameter discharge electrode, the arc length would be greater but the intensity would be less.

2. CONTINUOUS DISCHARGE
If you point a finger at the dome from a distance of about 3 inches, you will feel a slight tingle on a continuing basis. If there is more of an intermittent zap, move your finger a little closer until the current flow is continuous. Instead of a finger, now hold a common nail or metal screwdriver pointed at the dome. Be sure to hold the screwdriver on some part of the metal and not by the handle. The effect of the metal point is more pronounced than the finger but, in both cases, we are continuously discharging the dome. If you now bring the N-122 Electrode near the dome while holding the nail, you will not get an arc as before. When this demonstration is performed in the dark, you will see a faint glow around the point of the nail. This is called a corona discharge. It is the continuous excitation and ionization of the air, causing the emission of light.

3. THE ELECTRIC WIND
Repeat the previous demonstration while holding a candle flame between the point (nail) and the dome, but nearer the point. You will see that the flame is bent over by a wind that is blowing away from the dome. The effect is caused by charged particles of air trying to get away from the dome and from each other. (Like charges repel one another.) The same wind effect can be seen by placing the N-127 Point Terminal on the side of the dome and holding the candle several inches away. A child’s plastic pinwheel or a thin sheet of facial tissue are excellent demonstration devices.

4. THE ELECTRIC PLUME
Place the N-125 Electric Plume on top of the dome, making sure that the ribbons are not tangled with one another. When the machine is turned on and the voltage builds up, the ribbons will stand up and away from each other. They have acquired a negative charge from the dome and are repelled from it and from each other.

5. THE ELECTRIC WHIRL
Bring an N-124 Electric Whirl (or the N-124-IS Electric Whirl for use with N-140 Insulating Stand) near the dome when it is up to voltage. The three-arm pivoted assembly will immediately begin to turn. The direction of rotation will be away from the pointed ends of the spokes. What is happening is that the arms are being charged negatively by leakage from the dome and the points are in turn ionizing the air nearby. As these charged particles are repulsed by the point, there is also a reaction force that causes the arms to turn.

6. THE RACING BALL
Mount the N-141 Racing Ball assembly on top of the N-140 Insulating Stand and bring them near the dome. Connect a wire from the dome to the wire loop at the top of the Racing Ball. Any light-weight wire, either bare or insulated, will suffice. Ground the base of the Racing Ball by connecting a wire from the metal hook on the Insulating Stand to the binding post on the cabinet. If the pan of the Racing Ball is level, the ball will begin to roll around and will finally run continuously around the rim of the lower pan. The ball acquires charge from the upper disc and then is repelled, so it rolls. More charge comes in at the top of the ball and as it rolls further, the charge at the bottom of the ball is lost to the grounded lower pan.
7. THE HOLLOW CYLINDER
The N-142 Hollow Cylinder has small, lightweight pith balls tethered by threads. One pair of balls is on the outside of a metal cylinder and another pair is on the inside. When the unit receives a charge from a proof plane or an N-122 Discharge Electrode, the outside balls will become charged and stand away from the cylinder. There is no charge inside the cylinder and so the inside balls are totally unaffected.

The N-122 Discharge Electrode may be used as a proof plane. Charge up the Generator and then turn it off. Touch the N-122 to the dome and then use it to transfer charge to the small ball on the top of the N-142. The small N-135 Proof Plane will also work very well but you may have to recharge it from the dome several times.

This demonstration is best performed with the Hollow Cylinder at some distance away from the dome. If no transfer device is available, charge up the generator dome and then turn the machine off. Bring the electrode ball on top of the Hollow Cylinder up to touch the dome.

8. THE LIGHTNING PLATE
Hang the N-139 Lightning Plate on the small metal hook at the top of the N-140 Insulated Stand. The lower ring of the Lightning Plate should be connected to the grounding binding post on the cabinet base of the generator. Any light weight wire will be satisfactory. Now, when the Generator is in operation, small arcs will jump between each of the segments on the conductive surface of the Lightning Plate. Notice that the discharge follows the shortest cumulative distance to get to ground.

9. VOLTA’S HAIL STORM
Bring the N-132 Volta’s Hail Storm near the dome of the Generator and the small particles of vermiculite will immediately begin to jump up and down. They are first attracted to the upper plate, but when they get there, they receive a charge that causes them to be repelled. When the particles again reach the grounded lower plate, they lose their charge and then the process will repeat.

Just holding the base of the N-132 will usually provide enough grounding for successful operation. When the N-132-IS Volta’s Hail Storm is used with the N-140 Insulating Stand, the metal clip at the top of the stand should be connected to the grounding binding post on the cabinet.

10. SMOKE PRECIPITATION
Remove the vermiculite from the N-132 Volta’s Hail Storm (or the N-132-IS Volta’s Hail Storm for use with N-140 Insulating Stand) and stand the little piece of wire screen on edge. If necessary, roll the screen into a partial cylinder to help it stand on its side. Fill the N-132 with cigarette smoke or equal, replace the top and then bring the unit near the dome of the Generator. The smoke will immediately become charged and be attracted to one of the electrodes. It will vanish almost instantly.

11. NEON WAND
The N-146 Neon Wand is a very sensitive indicator of the extent of the electrostatic field near the dome of the generator. Pointing the glass tube at the dome from a distance of 2 or 3 feet will cause it to light up with the typical orange neon glow. As you bring it closer to the dome, it will become brighter. If you stick a small piece of foam on the wires at the end of the tube and then hold it against the dome, you should get the very brightest output. In this case, the foam is providing a small amount of insulation so that the dome has to build up to a high charge level before it can arc to the wires. The neon tube now receives a quick repetition of high-energy discharges that create more light than the continuous current flow that was present without the foam.

12. THE FLYING BALL
Hold the “fishing pole” of the N-144 Flying Ball so that the ball is perhaps 6 or 8 inches from the dome. Note carefully that, at first, it is attracted to the dome, but if it touches the dome, it is then violently repelled. Until this newly acquired charge is dissipated, the ball will “fly” at the end of its thread and remain quite far from the dome. If you touch the ball and thereby remove the charge, the performance will be repeated. First, attraction by induction, and then repulsion after it touches the dome. The round, smooth shape of the ball allows it to hold a charge for quite a long time.

13. THE SILVER SNAKE
The N-144 Silver Snake is a metallized ribbon that will be attracted to the dome, but repelled as soon as it touches. Its geometric shape with edges causes the loss of charge into the air very quickly and so the cycle repeats.
14. CHARGING A PERSON’S HAIR
This is fun for all the class but not necessarily an easy demonstration to pull off. If you can raise the entire person to the voltage level of the dome, then their hair should act in much the same way as the electric plume did in paragraph No. 4.

The first step is to insulate the subject from ground by having them stand on something like a sturdy plastic milk crate or some glass building blocks. You need to get the subject about one foot above the floor. A rubber mat or plastic sheet simply will not work. Have your volunteer place his or her hand on the dome and then start the machine. The subject must understand that he is not to remove his hand or he will receive a shock when he puts it back. In a minute or so the subject will have been raised to about as high a potential as you’re going to get. If the hair is now standing up, you have succeeded. If not, it’s time to consider what might be wrong.

First, the N-100V is not a huge machine, so the smaller the person you have selected, the better. There will be less surface from which to lose charge. Second, be sure there are as few “points” of loss as possible. Things like rings on fingers, metal barrettes, and belt buckles should be avoided. Third, be sure the machine is in good operating condition and is putting out plenty of voltage. Do not even think about trying this demonstration on a day of high humidity. The generator output will be low and leakage will be high.

The repulsive forces available are relatively small and are quite insufficient to untangle hair or overcome any type of hair spray. The best results will come from clean, straight, dry hair of perhaps 3 or 4 inches in length.

For more information about these Van de Graaff Generator demonstrations, or for questions or suggestions pertaining to this instrument, please contact us at info@winsco.com, or visit our website at www.winsco.com. We are continuously making additions and updates to our website, so please check in often.