



INSTRUCTIONS

VAN DE GRAAFF ELECTROSTATIC GENERATOR MODEL N-100V

UNPACKING AND INSPECTION

Carefully unpack the unit in accordance with instructions printed on the box and immediately inspect for damage which may have occurred during transit. If any signs of damage are noted, file a claim at once with the carrier. Save all packing materials so that they may be inspected by the carrier's claim representative. If the shipment was made by United Parcel Service, notify the dealer from whom the unit was ordered and he will assist you in handling the claim. It is again imperative that all packing materials be retained for inspection. All units are shipped completely assembled and ready for operation.

DESCRIPTION OF EQUIPMENT

The model N-100V electrostatic generator is designed to attain potentials up to 350,000 volts under favorable operating conditions. Potentials of 250,000 volts are more usual and provide more than enough for forceful demonstrations.

The variable speed motor is controlled by the rheostat on the front panel. When the unit is new, it is normal for the motor to not start turning until the rheostat has been turned past the half-way point. This is because the bearings in the motor and the upper pulley are still relatively tight.

When a person is near an operating machine, it is inevitable that he will become charged, especially if wearing rubber-soled shoes. When you reach for the on-off switch, you will necessarily get a shock as your body discharges to ground. To avoid this shock, keep your person

at ground potential by holding onto a bare, uninsulated wire which has been connected to the ground binding post.

MAINTENANCE

Keep the dome and column free from dust and finger-prints. Clean with a soft damp cloth. Film cleaner or alcohol will remove any finger-prints or oils.

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.

It is strongly recommended that you retain the shipping carton and packing materials. They will be very useful in storing the unit safely or in returning it for service. Should it ever be necessary to ship the unit, be sure to apply two or three pieces of tape across the seam between the upper and lower halves of the dome. This will help prevent the two halves from separating because of shock or vibration and thereby assure the greatest resistance to shipping damage.

INS5011

WABASH INSTRUMENT CORPORATION

300 OLIVE STREET

WABASH, INDIANA 46992

MY VAN DE GRAAFF IS SICK

It sure seems to be a cantankerous and unpredictable device that never works quite as well as you would like, and sometimes not at all. Before we dismiss the Van de Graaff generator as just another bummer, perhaps a review of its principle of operation will help us better understand why it is such a fickle instrument.

Surely you all remember exactly how it works, but just in case your recollection is a little foggy, let's run it by one more time. A rubber belt, stretched between two pulleys, is motor driven at a moderate speed. The separation of the belt from the lower, felt covered pulley strips away from the felt all the available electrons. The moving belt carries the charge up to the smooth pulley inside the dome at the top of the column. Without much ado and absolutely no help from the government, the upper pulley acquires a negative charge. When additional charges arrive on the belt, they are repelled and jump the airgap to the upper brush electrode. This electrode is connected directly to the dome and the charge immediately tries to leave town. Since like charges repel one another, they all try to get as far away from each other as possible, forcing them to the outside surface of the dome. For the moment, that is as far as they can go. The belt continues to bring more charge to the upper pulley and thence to the dome, and its potential increases. This rise in potential will stop only when some sort of equilibrium is reached with the rest of the world. Just what does limit the maximum voltage?

The most important factor is the resistance of the insulation between the dome and the ground plane which is, in this case, the base of the machine. Obviously, the clear plastic support column can be made from a very high resistance material, but the real trouble-maker in this discussion is the air. There is an enormous difference in resistance between dry air and moist air. When the relative humidity is high, the charge on the dome is drained through the air to ground before it can build to a high potential. On the other hand, when the furnace is on during the winter and the relative humidity drops way down, the charge can build to an exciting level; now the voltage limit is closely related to the size of the dome.

There are other factors which influence the potential on the dome. Dust on the surface provides many "points" which help drain the charge more easily into the air than a clean surface. The distance of the dome from the ground plane also is important. While the design of the model N100-V provides plenty of clearance from dome to base, the ground plane also includes any nearby overhead light fixtures as well as other equipment that may be on the table.

CARING FOR THE SICK

One of the realities of operating a Van de Graaff is that a small amount of ozone is created. And it eats latex. The transport belts deteriorate with time anyway, just as do ordinary rubber bands. The ozone just speeds up the process. In normal classroom operation, we would expect a belt to last three or four months. Most teachers find that the belt needs replacing one year after the last use. At any rate, we suggest you keep on hand only one spare belt as they do have a finite shelf life.

Perhaps the most plaintiff phone calls we get relate to a unit which has not been operated since it was carefully put away the previous year. It simply won't build up any voltage, or so little as to not be useful. Over time, the "felt" on the lower pulley may absorb moisture. When this happens, the triboelectric effect is minimal. That is to say, there is but a slight tendency for the belt to pick up a charge as it separates from the pulley. For schools in places like Minnesota this is not usually a problem, as the long months of furnace heat keep the relative humidity very low. But Louisiana is another story. What to do? The best remedy we have found is to unplug the unit, remove the bottom of the cabinet, remove the belt and lay the unit on its side...carefully! Then plug it back in and, keeping fingers out of the wiring, run the motor at low speed while directing the output of a hairdryer at the pulley. Remember that the goal is merely to dry out the felt, not to set fire to some paint or melt insulation on the wires. Keep the dryer far enough away to assure safety. Twenty or thirty minutes should do the job.

After you have finished with the hot air, it may also be helpful to rough-up or raise the nap on the felt. Use some coarse sandpaper with very light brushing strokes. Then install that new belt you've been saving. Put the cabinet bottom back in place and everything should be back to normal until it's time for another blow-dry treatment.

Another helpful housekeeping chore is to remove accumulated dust particles for the dome. A clean cloth with a little film cleaner will do the job and remove fingerprints at the same time.

AND OTHER STUFF

Whenever a person is near an operating machine, that person will unavoidably acquire a charge. This will be especially true if he or she is wearing rubber soled shoes. Now when it comes time to reach for the power switch to turn the machine off, there is a shocking discharge from the person to the switch which is grounded to the case. This is all very logical but we still get twenty or thirty calls a year complaining that the machine is not properly grounded or that somewhere there is an electrical short.

If you would prefer to avoid this little surprise tingle, you have but to keep yourself at ground potential. And to do this, all that is necessary is to drain your personal charge to ground as fast as it arrives. Hold a bare, uninsulated wire in your hand and connect the other end to the grounded binding post on the base of the machine. You can still get zapped if you put your nose up close to the dome, but you will no longer accumulate a charge.

One of the most frequently asked questions relates to the positioning of the upper and lower brush electrodes. Many callers are under the impression that the closer these electrodes are to the belt, the better the system will operate. Referring back to our earlier discussion should lead you to understand that these brushes only provide a relatively low resistance path for the movement of electrons either from ground to the lower pulley or from the upper

pulley to the dome. Sure they help the system work or else they wouldn't be there, but by and large they don't play a significant role in the ultimate potential reached by the dome. When the machine is operating in a fairly typical manner, there is more than enough potential at either pulley for the electrons to jump any reasonable gap. Set the brushes about 1/8" to 1/4" inch away from the belt and forget them.

After several years of faithful service and being shoved around in dark closets, it is not uncommon to find that the dome has become dented. Does this mean a replacement is in order? Well, not really. Dents are certainly not helpful, but they are by no means the signal to hold services for an old friend. Smooth out the dents from the inside using a spoon or similar tool and a piece of wax paper to reduce the friction. There will be some loss of maximum potential because of the less than smooth surface but amount will be unimportant.

The speed control on the N-100V is a simple rheostat and series resistor. As you all must remember from electricity 101, an AC-DC or universal motor has relatively poor starting torque. When the motor and upper pulley bearings are new and tight, it may require a considerable reduction of the series resistance to overcome the "break away" frictional torque. In other words, you may have to turn the rheostat quite far in order to get the motor started. After ten or fifteen hours of operation, the motor starting point on the rheostat will be much earlier.

We are always pleased to hear from teachers who may have comments or suggestions about our products or their instructions. If you know of a new or better procedure and would like to share it with your colleagues, please write, or FAX us at 219-563-8400, to the attention of Manager, School Product Engineering.



INSTRUCTIONS

INS 5051

WARNING

THE DEMONSTRATIONS DESCRIBED IN THESE 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.



INSTRUCTIONS

SUGGESTED DEMONSTRATIONS

1. THE DISRUPTIVE ARC

One of the most spectacular attention getting demonstrations that can be done with 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 base of the generator. If the generator is operating up to voltage, there will be a sharp crack and a bright bluish-white arc will jump from 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 arc length. With a smaller diameter discharge electrode, the arc length will be greater but the intensity will 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. Repeat this while holding a common nail or metal screw-driver pointed at the dome. Be sure to hold the screw-driver 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 bring the N-122 electrode near the dome while holding the nail, you will not get an arc as before. When this demonstration is done in the dark, you will see a faint glow around the point of the nail. This is called corona discharge. It is the continuous excitation and ionization of the air which causes the emission of light.

3. THE ELECTRIC WIND

Repeat the previous demonstration while holding a candle flame between the point and the dome but nearer the point. You will see that the flame is bent over by a wind that is flowing away from the point. The effect is caused by charged particles of air trying to get away 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.

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 now each repels the other. They are spread out by the repelling forces.

5. THE ELECTRIC WHIRL

Bring an N-124 electric whirl 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 the dome and the points are in turn ionizing the air nearby. As these charged particles are repulsed, there is a reaction force which causes the arms to turn.

INS5011B

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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. Also be sure to ground the base of the racing ball by connecting a wire from the insulating stand to the binding post on the base of the machine. 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 on 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 hollow cylinder, N-142, has small light-weight 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, the outside balls will become charged and stand away from the cylinder. There is no charge inside the cylinder and the inside balls are totally unaffected.

It may be difficult to make this demonstration with an operating generator as the electric wind tends to neutralize the charge on the balls.

Use the N-122 Discharge electrode 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. You may have to do this more than once in order to transfer sufficient charge. The small proof plane, N-135, will also work very well but you may have to recharge it from the dome several times.

8. THE LIGHTNING PLATE

Hang the lightning plate, N-139, on the arm of the N-140 insulated stand. The lower ring of the lightning plate should be connected to the grounding binding post on the base of the generator. Now, when the generator is in operation, small arcs will jump between each of the segments on the conductive surface of the lightning plate. Given a lower resistance path to ground than through the air, the arc will choose to follow it. Notice also that the discharge closely follows the shortest distance 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 which causes them to be repelled. With the lower plate of the N-132 grounded, the charge will be lost when the particles again reach the lower plate and then the process will repeat.

10. SMOKE PRECIPITATION

Remove the vermiculite from the N-132 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 attracted to one of the electrodes. It will vanish almost instantly.

11. NEON WAND OR FLUORESCENT TUBE

Hold a small neon tube or 20 watt fluorescent tube near the generator and they will glow. They will not be up to their usual brilliance but current is passing through them and some light will be emitted.

12. THE FLYING BALL

Hold the "fishing pole" of the N-144 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.

13. THE VANE ELECTROSCOPE

The vane electroscope, N-131, is a moderately sensitive device that shows the presence of electrostatic charges. Touch the N-135 proof plane to the dome of the generator and then bring it near, but do not touch, the ball at the top of the vane. The arm will stand out at an angle dependent on the amount of the charge. As soon as the proof plane is removed from the vicinity, the arm will return to its original position. Next bring the proof plane back and this time touch the ball at the top of the vane, thereby transferring a charge to it. Now the arm will stand out and remain so even when the proof plane is removed from the vicinity.

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 a 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. 3.

The first step is to insulate the person from ground by having them stand on something like a sturdy plastic milk crate. Have your volunteer place his 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 person 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.

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.

We are always pleased to hear from teachers who may have comments or suggestions about our products or their instructions. If you know of a new or better procedure and would like to share it with your colleagues, please write, or FAX us at 219-563-8400, to the attention of Manager, School Product Engineering.

SE - 8691

WINSKO

N100B Belt Instructions

REPLACING TRANSPORT BELT

Model N-100V Electrostatic Generator

Unfortunately, the ozone created during the normal operation of a Van de Graaff generator attacks and eventually destroys the latex rubber transport belt. Following is the suggested procedure for installing a new belt.

Be sure your hands are *clean* and *dry* when handling the new belt - wear thin cotton or nylon inspection gloves if available.

1. Unplug the line cord from the electrical outlet. Caution: Do not proceed until this is done.
2. Carefully remove top half of the polished dome and set it aside.
3. Remove the six (6) cabinet screws from the sides and top of the base. Lift the upper half of the machine clear of the cabinet bottom and set it down carefully in a horizontal position. If there still is an old belt installed, slip it off the lower felt covered pulley. Now stand the machine vertically, remove the upper pulley and discard the old belt. Hang the new belt over the upper pulley and re-insert the rubber sleeves into the slots in the top of the column, allowing the excess belt material to hang down inside the column.
4. With care, lay the unit on its side and reach up inside the column from the motor end and catch the loop of the belt with a stiff wire bent to an L-shape. Pull the belt down and slip it over the lower felt covered pulley.
5. Stand the machine vertically again and connect the line cord to 115 volt, 60 Hz electrical outlet. Start machine at slow speed and check to see that belt tracks correctly. If it does not track, press down on one or the other of the rubber axle sleeves to force the upper pulley into proper alignment.
6. Unplug the line cord from the electrical outlet.
Caution: Do not start re-assembly until this is done.
7. During the installation process, the brush electrodes will necessarily have been moved. They should now be re-positioned with the points of the screen perpendicular to the belt and parallel to axis of rotation of the pulley. The points should be approximately 3/16" from the belt - not closer.
8. Re-assemble the cabinet and dome. Wipe outside surface of dome to remove any dust or grime. A solvent such as photographic film cleaner is very effective.