OPERATING INSTRUCTIONS

Large Electrostatic Generator with Discharger

CP33891-00

Fig.1: CP33891-00 Large Electrostatic Generator with

1. Introduction

The Electrostatic Generator with Discharger (CP33891-00) is a convenient source of high-voltage static electricity. Based on the well-known Van de Graaf system, this redesigned model incorporates the best features of earlier successful machines of this type for demonstrating the generation of high-voltage static electricity. The generator can produce 250,000 volts or more, depending on the air humidity at the time of operation. Currents are a few microamperes, sufficient for a variety of static electricity demonstrations.

2. Description

2.1. General

Inside the ends of a transparent, non-conducting, hollow vertical column, two pairs of insulating pulleys are mounted on horizontal roller bearings. Twin insulating belts connect the pairs of pulleys. The common shaft of the lower pulleys extends outside the column where it is coupled to the

shaft of an electric motor. When operating, the motor turns the lower pulley pair to drive the belts.
A metal "knife edge" is mounted near each pulley pair so that the knife edge points directly at the pulleys and is approximately 3mm (1/8 inch) away from the place where the belts run over the pulleys.
The knife edge near the lower pulleys is attached to a grounded metal base, making electrical contact with it. The knife edge near the upper pulleys is mounted directly onto the inside of the collector sphere.
The collector sphere is a removable polished thin metal sphere that fits over the top of the column and rests on three small supports attached to the outside of the column. An auxiliary conducting sphere, smaller than the collector sphere, is attached to a vertical rod which is mounted through a spring onto the metal base. The center of the auxiliary sphere is at the same height above the metal base at the center of the mounted collector sphere. A binding post, mounted on the base cover next to the slot where the rod emerges, is connected to the grounded terminal of the power cord and to the base. The post can also be used as an auxiliary grounding point.

2.2. Principle of Operation

As the belts travel at high speed over the pulleys, the lower knife edge sprays electrons onto the outer surfaces of the belts. The belts carry these electrons up the column and inside the collector sphere toward the upper knife edge. Electrons in the knife edge, repelled by the electrons approaching on the belts, migrate from the knife edge onto the collector sphere and distribute themselves evenly over the outside of the sphere. By losing electrons to the sphere, the knife edge becomes positively charged with respect to the approaching surfaces of the belts and the high electric field at the knife edge causes the electrons on the belts to jump onto the knife edge.
By this process, the large collector sphere continuously acquires electrons from the upward-moving sections of the belts until it is charged to its equilibrium value (about 250,000 volts with normal separation of the collector and auxiliary spheres) before discharging to an external object or to the auxiliary sphere mounted on the base.
After the belts lose their excess electrons to the upper knife edge, their charge becomes positive with respect to ground. The positively charged sections of the belts travel downward toward the lower pulleys and knife edge. The potential difference between the positive sections of the belts and the grounded lower knife edge causes electrons to jump from the knife edge onto the belts, starting a new charging cycle. Electrons lost from the knife edge are immediately replaced from ground. The electron transfer between the belts and the knife edges can be seen as a continuous sparking, or a corona discharge. The felt covering of the lower pulleys assists in maintaining the insulation of the belts from ground and provides the initial charges to start the process.

3. Setting Up the Apparatus

Unpack and assemble the generator according to the attached instruction sheet "STATIC GENERATOR ASSEMBLY". Set the generator on a firm surface and insure that there is adequate free space (at least 30cm) around the collector sphere. If necessary, remove any nearby grounded objects that could receive a discharge from the generator.

CAUTION: Take care when moving the generator to prevent accidental cracking of the hollow column. Hold the apparatus by both column and base to prevent undue stress being placed on the junction of the cylinder and base.

Set the motor speed adjusting knob to the "OFF" position (fully counterclockwise) then plug the line cord into a 115VAC three-prong outlet.

4. Operation

CAUTION: Do not operate this unit near computers, electronic equipment, or sensitive apparatus such as leaf-type electroscopes that might be damaged by a strong electrostatic field.

After the unit has been properly assembled and connected, it can be operated. Turn the motor speed switch on the front of the base cover clockwise to start the drive motor. Note that the highest speed

setting is located next to the “OFF” switch position. Further clockwise rotation of the knob selects slower speeds. The belts will begin to charge the collector sphere.
Discharges, evidenced by sparks and crackling noises, will take place periodically between the two spheres. The frequency and intensity of the discharge can be varied by adjusting the distance between the two spheres. This can be done by applying pressure to a side of the rod with a wand made of insulating material — a meter stick or a wooden ruler is suitable. Always keep the wand closer to the collector sphere than to any portion of your body.
The rod holding the auxiliary sphere can also be removed by unscrewing it from the base. This feature lets you hold the rod and sphere in your hand and walk around the unit.

CAUTION: Before removing the rod, ground it by clamping a grounding wire between the knurled nut and the sphere and connecting the free end to the binding post on the base. Failure to do so will lead to an electric shock!

To enhance the visibility of the spark effect produced by the electrons’ discharge, operate the unit in a darkened room.
After completing the demonstration, switch off the unit and bring the auxiliary sphere in physical contact with the collector sphere until no evidence of discharge is detected.
The dielectric breakdown voltage of dry air is 3×10^6 volts per meter. The actual voltage at which discharge occurs between the two spheres is, therefore, the distance between the spheres multiplied by the dielectric breakdown voltage. Thus, if the separation between the spheres was 10cm (0.1m) at the time of discharge, the voltage on the collector sphere was 300,000 volts.
Many interesting experiments can be performed using this apparatus and a range of accessories, including a gold-leaf electroscope (kept at a safe distance from the generator); an assortment of friction rods; a hollow globe; and a Leyden jar. Perform each experiment several times and describe the distribution of the charges and the nature of the electric fields with diagrams. Describe each effect in terms of the redistribution of charge on the body and also in terms of the potential changes that it undergoes.

4.1. Study of the Electroscope

Ground the case of the electroscope by connecting it to a water pipe or gas line and charge it inductively with a hard rubber friction rod that has been rubbed to create a negative charge (see Figure 2).
Note the approximate distance of the inducing rod from the electroscope when the ground was broken. Then take the inducing rod some distance away and approach the electroscope, coming closer to

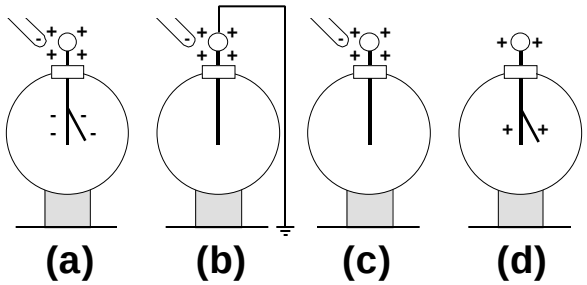

Figure 2 Charging an electroscope by induction

it than before. Note the behavior of the leaves.
Leaving the electroscope charged as before, rub a glass friction rod with silk and observe the behavior of the charged electroscope as the charged glass rod is brought near. Repeat, using various other substances in place of the glass rod. Begin a new experiment, this time including the initial charge on the electroscope with the glass rod, and observe the results.

4.2. Distribution of Charge on a Hollow Sphere

Charge a hollow sphere by holding its insulating support in one hand and touching the sphere briefly to the generator. Investigate the distribution and sign of the charge by touching a proof rod to various points on the inside and outside of the sphere, testing it each time by bringing it near an electroscope that has a charge of known sign. Using a fine wire, connect the proof rod to the electroscope and again probe the charge on the inside and outside of the sphere, taking care not to touch the wire. Explain the difference between the results of these two observations, and illustrate by diagram.

4.3. Faraday's Ice Pail Experiment

Charge a Leyden jar by holding the base in one hand and touching the knob to the generator. The Leyden jar serves as a reservoir for charge; small amounts can be removed as required with the proof rod. Transfer a small charge to the electroscope and test the sign of the charge by bringing up the negatively charged rubber rod.
Connect the insulated sphere to the knob of the electroscope with a length of wire. Give the proof rod a charge of known sign and insert it carefully inside the hollow sphere, taking care not to make contact with the sphere. Test the sign of the charge on the electroscope when the proof rod is inside the sphere. Remove the proof rod and note the behavior of the electroscope.
Again insert the proof rod and hold it inside the sphere without making contact. Observe the behavior of the electroscope as the sphere is grounded, the ground broken, and the charged proof rod is removed from the sphere. Test the sign of the final charge on the electroscope.
Insert the charge proof rod once more without making contact. Ground the sphere as before. After the ground is broken, touch the proof rod to the inside of the sphere and note carefully the behavior of the electroscope. Remove the proof rod and test the sign of the charge on the electroscope.

5. Maintenance

5.1. General

After the apparatus has been in use for some time, it may become necessary to clean the belt, pulleys, and column to remove dust and other particles that accumulate readily on the charged surfaces. Always unplug the unit before cleaning these parts. Wash them using only grit-free soap, clean water, and a clean, soft cloth. Dry-wiping or wiping with a gritty cloth will scratch the plastic column. Grease and oil deposits can be removed by using a soft cloth wetted with methanol or kerosene, followed immediately by washing with soap and water. Never use razor blades or other sharp instruments to remove deposits.

Keep the spheres and outside of the column free from dust and dirt. Accumulation of dust on these parts is greatly enhanced by the strong electric fields. A dust layer can substantially reduce the performance of the generator by facilitating the leakage of charges from the collector sphere.

5.2. Belt and Pulley Replacement

Always unplug the unit before cleaning it or replacing parts.
To remove the belts for cleaning or replacement, follow the procedure describe in the attached sheet "BELT CHANGE INSTRUCTIONS"
If you should experience any difficulty with the apparatus, please contact CENCO Physics, giving details of the problem. To ensure better service, please do not return any item until we have sent you authorization.

6. Replacement Parts and Accessories

Description	Cat. No.
Replacement Belts (Pair)	CP33891-50
Electrostatic Accessories Set	CP71899-00
Closed Case Form Electroscope	WL1963A
Hard Rubber Friction Rod	WL1929
Glass Friction Rod	WL1926
Hollow Globe	CP79075-00
Leyden Jar	WL1990
Proof Plane	WL2019

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