Apparatus Competition
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Low cost Electrostatic generators made from FunFlyStick™ toy

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Abstract

The Fun Fly Stick™ electrostatics toy (about $30 from various sources) can be easily modified for use as an inexpensive table-top Van de Graaff generator, or as a dipole electrostatics generator for experiments with electrostatic circuits. The modified generator reaches about 60 kV, has a capacitance of about 6pF and is equivalent to a VDG with a diameter of about 12 cm.

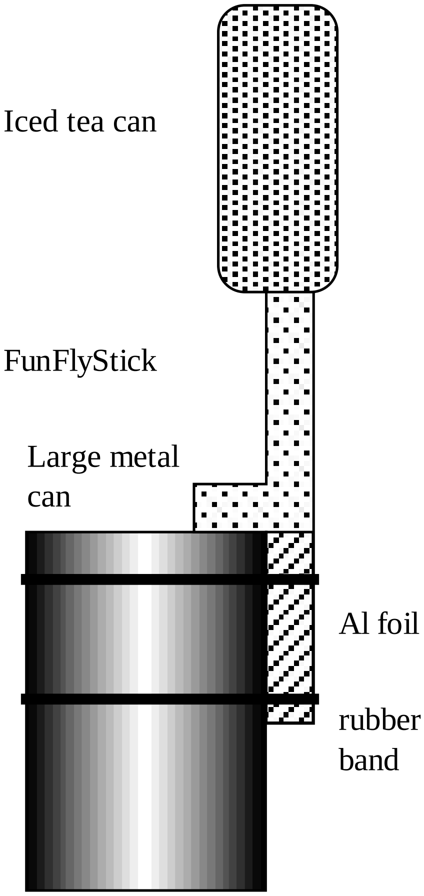
Construction of Apparatus:

The Fun Fly Stick™ is a hand held Van de Graaff generator (VDG) run by two AA cells, with an internal belt giving a positive charge to a cardboard collector. Its intended use is to levitate lightweight shapes of aluminized Mylar™. The generator ground is a ring around the push button switch on the handle which grounds it to the operator. The generator charges the cardboard collector positively relative to ground. A small DC power supply (3V, 2 A) could be used to replace the batteries if desired.

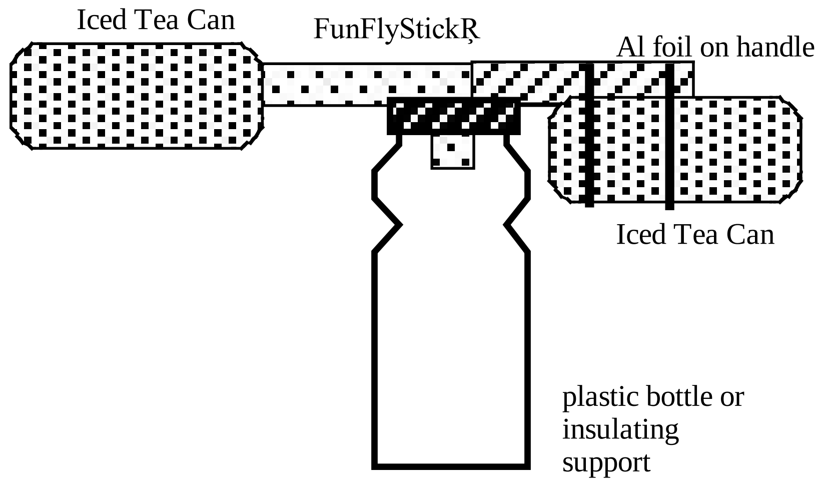
To convert it to a table-top VDG, remove the cardboard collector tube and replace it with an empty 23.5 oz pop top aluminum drink can (e.g. Arizona™iced tea can) pushing the mouth of the can over the end of the Fun Fly Stick™ with the can tab contacting the collector brush on the Fun Fly Stick™. Wrap the handle with heavy duty aluminum foil so the foil covers the push button switch. Use large rubber bands to fasten it to an empty inverted No. 10 tin can (106 oz capacity) with the switch facing out. The switch can be held closed by the upper rubber band or by a small flat stick held by the rubber band and swung over the switch.

To make a dipole generator instead, attach a second large aluminum can to the foil wrapped handle with rubber bands. Support the generator horizontally, inserting the motor bulge on its side into an insulating support such as an empty 20 oz. plastic drink bottle (e.g. Gatorade™ bottle) filled with rocks or sand for stability. Hold the switch closed by a rubber band or a flat stick fastened to the handle with a rubber band. Wires or foil wrapped straws can be used to connect the positive and negative terminals to electrostatic equipment such as an electrostatic motor, Leyden jar, neon bulb, etc.

Iced Tea Can Van de Graaff generator



Dipole electrostatic generator



Use of Apparatus:

The typical laboratory VDG is expensive and makes relatively large sparks, suitable for demonstrations but not for student use in the laboratory. The generators described here are cheap enough and small enough to be used in a small classroom for demonstrations and can also be used for laboratory experiments.

Experiment – measuring the maximum charge. An initial attempt was made to measure the maximum charge directly using a Vernier Electrostatic Charge sensor and a computer. The peak charge turned out to be beyond the range of the Vernier sensor (maximum q = 100nC). An experiment was designed to measure the charge by a charge sharing process. The generator was set near an empty No. 10 can resting on a glass jar on top of an aluminum foil ground plane. The can and ground plane were connected to the leads of the charge sensor[i]. The Iced Tea Can Van de Graaf generator (ITC-VDG) was placed near the sensor set up and operated until the charge sensor reading leveled off. (See graph below.)

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

The ITC-VDG was now turned off and a second iced tea can with a plastic straw as an insulating handle was touched to the ITC-VDG, taking half the charge. This can was now lowered into the sensor can, acting as a faraday pail and giving up its charge to the sensor. The resulting charge was still outside the range of the sensor. The sensor and can were grounded and the sharing process repeated. The transfer can now held ¼ of the peak charge of the ITC-VDG, which was still outside the sensor range. Repeating the procedure again with 1/8 of the peak charge gave a value of 45 nC. Repeating with 1/16 and 1/32 gave 24 nC and 10 nC, giving an estimated peak charge of about 350 nC (see graph below.)

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Experiment – determining peak voltage of ITC-VDG.

A spark gap made from two brass spherical drawer knobs with 3.1 cm diameter was used to estimate the maximum voltage of the ITC-VDG. One sphere was attached to the iced tea can, and the second was attached to the grounded base. The charge sensor was placed nearby to monitor the charge state, and the sphere gap was adjusted until the VDG reached its maximum charge before the spark occurred as shown in the graph.

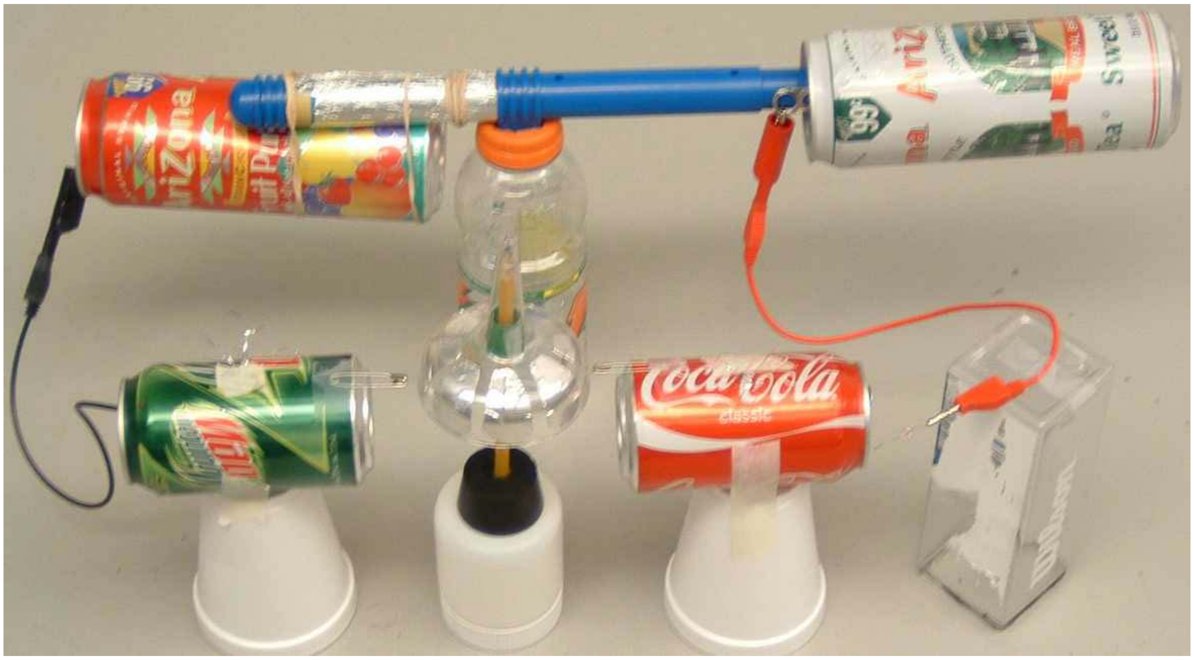
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

The sphere spacing of about 2.4 cm was compared with the tables in A. D. Moore's classic book Electrostatics[ii] to obtain a maximum voltage of about 60 kV. From the voltage and charge, the capacitance of the ITC -VDG can be estimated as 6 pF. The online demonstration book at the University of Wisconsin[iii] gives the capacitance of VDG's at about 1.1 pF/cm of radius, making this equivalent to about a 12 cm diameter Van De Graaf generator.

Dipole Generator uses.

Because the FunFlyStick™ is battery powered, there is no need for one terminal to be at ground potential. The dipole generator can serve as an electrostatic analog of an ungrounded DC power supply or battery. Students may not realize the circuital nature of electrostatic phenomena because the return path of charge is often obscure, charge flow is not constrained to wires, local charge imbalances are obvious and charge transfer is often not continuous. By contrast, in simple DC circuits, wires constrain return paths making the circuital nature more obvious, local charge imbalance is hard to detect, and continuous charge flow is most common. With the ungrounded dipole generator, it is possible to set up electrostatic circuits that mimic the features of simple DC circuits, and can help students develop a more unified understanding of electrical phenomena.

The picture below shows a circuit containing a neon bulb and an electrostatic motor. The cans on either side of the rotor have tinsel sprays attached to indicate charge imbalance.



Cost of Apparatus:

(note – parts for 1 generator- does not include equipment for experiments)

Fun Fly Stick™	from Teachersource.com		$26.95
No. 10 can	free from kitchen trash		$0.00
iced tea cans	free from trash		$0.00
Gatorade™ bottle	free from trash		$0.00
rubber bands	office supply store	$1.69/box	$0.10 approx
Aluminum foil	from kitchen		$0.05
		TOTAL	$27.10 or so

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[i] Morse, Robert A., *Electrostatics with Computer-Interfaced Charge Sensors*
The Physics Teacher, Volume 44, Issue 8, pp. 498-502 (2006).

[ii] Moore, A.D., Crowley, Joseph M., Electrostatics: Exploring, Controlling and Using Static Electricity, 2nd ed., Laplacian Press,1997.

[iii] http://sprott.physics.Wisc.edu/demobook/chapter14.HTM