http*://www.amasci.com/emotor/icepail.html*

SOME VDG-SPHERE THEORY

(c)1996 William J. Beaty

Figures one through five are a crude depiction of the "Faraday Icepail Effect" which is at the heart of Vandegraff generator operation.
It was Michael Faraday who discovered that whenever a small object having excess electric charge was placed inside a metal ice pail, the pail seemed to become charged immediately. Also, if the small object was conductive, then if he touched the object to the inside of the pail, the ice pail would steal ALL the excess charge from the small object. The small object became neutral and the metal pail remained charged. Very strange, no? Wouldn't you expect the excess charge to share between the pail and the object? It can share in this way, but only if the small object is touched to the OUTSIDE of the metal pail. Charged objects placed within metal containers behave very strange.

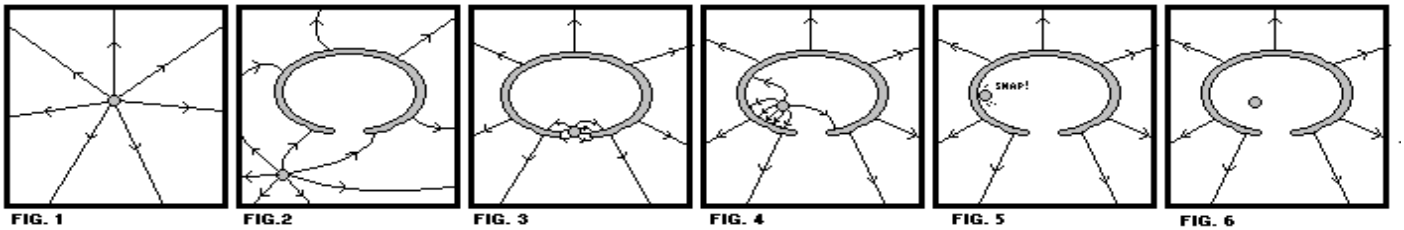

FIG. 1
A CHARGED METAL BALL AND THE E-FIELD. (REPRESENTED BY LINES)

FIG.2
CHARGED METAL BALL APPROACHES A NEUTRAL HOLLOW SPHERE.

FIG. 3
CHARGED BALL GOES INSIDE.

FIG. 4
CHARGED BALL INSIDE HOLLOW SPHERE.

FIG. 5
CHARGED BALL TOUCHES THE INSIDE OF THE HOLLOW SPHERE AND LOSES ALL ITS CHARGE TO THE SPHERE.

FIG. 6
NEUTRAL METAL BALL CAN NOW BE REMOVED.

FIGURE 1. The charged metal bead is surrounded with an electric field. Don't be misled by the sparse "field lines," this field actually fills space completely and is not divided into widely separated lines. I drew the lines merely to show the intensity and direction of the field. Note that electric fields are measured in terms of volts per meter, so in a certain sense, an electric field is MADE of electric potential. We could say that an electric field IS VOLTAGE.
FIGURE 2. Note that the hollow metal sphere is initially UNCHARGED: it has just as many field-lines leading into it as leading out.
FIGURE 3 & 4. As the charged metal bead approaches and penetrates the uncharged metal sphere, notice that the field lines arrange themselves on the outside of the hollow sphere as if the sphere was already charged. Also, once the charged bead is inside the hollow sphere, movements of the small bead do not affect the field outside.
FIGURE 5. When the metal bead touches the inside of the hollow sphere, the e-field lines concentrate between the bead and the inner surface, then they vanish. Rather than sharing charge equally, ALL the excess charge on the metal bead travels to the hollow sphere.
In the language of physics textbooks, the charge-imbalance on the small bead INDUCES an equal and opposite charge on the inner surface of the hollow sphere. This leaves the rest of the hollow sphere with an imbalanced charge which is exactly equal to the excess charge on the

small bead. This excess charge on the surface of the sphere spreads out, and the position of the charged bead cannot affect it.

What would happen if a constant stream of charged beads was delivered to the inside surface of the hollow metal sphere? The sphere would steal their charge, and the excess charge on the sphere would rise and rise without limit! No matter how strong the charge grew on the outside of the hollow sphere, you could still insert a charged bead and have it deliver ALL of its charge to the hollow sphere. The charged beads think that the inside of the hollow sphere is "ground." The hollow sphere seems to have an INFINITE CHARGE SUCTION EFFECT!

The VandeGraaff Electrostatic Generator uses this effect to attain enormous voltages. Rather than delivering small balls, a charged rubber belt is used to deliver a continuous stream of excess charge to the inside of the hollow sphere. Even though the belt-charging section in the base of the machine may only be capable of a few thousand volts, the belt "thinks" it's delivering its charge to the inside of a grounded sphere. As long is the belt is moving, the voltage and excess charge on the hollow sphere will keep rising and rising. In theory it will rise forever, but in the real world it is limited by dirt and sharp edges on the sphere, by the curvature of the sphere, by conductivity of the belt and the support column, and by the distance between sphere and ground and nearby objects. (Yes, the voltage on your VDG will momentarily change when you reach your hand out towards it. The voltage level will fall.)