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HOW A FARADAY CAGE WORKS

Electricity is the lifeblood of many aspects of our world. Without volts and amps, many of our technological innovations would cease to exist. Even our bodies wouldn't function without an electrical charge zipping through our cells. But what electricity gives, electricity can take away.

Although this form of energy is vital to so much of our lives, it's one of those things that are only good in the right amounts. Too much electricity can electrocute people. Likewise, it can kill our modern electronics and machines.

But thanks to Michael Faraday, the brilliant 19th-century scientist, and one of his namesake inventions, the Faraday cage, we humans have developed plenty of ways to control electricity and make it safer for our computers, cars and other inventions -- and for us, too.

Faraday cages shield their contents from static electric fields. An **electric field** is a force field surrounding a **charged particle**, such as an electron or proton.

These cages often look distinctly, well, cagelike. Some are as simple as chain-link fences or ice pails. Others use a fine metallic mesh. Regardless of their exact appearance, all Faraday cages take electrostatic charges, or even certain types of electromagnetic radiation, and distribute them around the exterior of the cage.

Electromagnetic radiation is all around us. It's in visible and ultraviolet light, in the microwaves that cook our food and even in the FM and AM radio waves that pump music through our radios. But sometimes, this radiation is undesirable and downright disruptive. That's where Faraday cages come in.

As a Faraday cage distributes that charge or radiation around the cage's exterior, it cancels out electric charges or radiation within the cage's interior. In short, a Faraday cage is a hollow conductor, in which the charge remains on the external surface of the cage.

That basic function has plenty of fascinating uses in our electrically cluttered and technology-packed world. And although Faraday would eventually have his day, the backdrop for his invention actually has its roots in earlier times. So, where did the idea for these ultra-useful cages come from?

Franklin's First Findings

It was Ben Franklin who helped inspire many of the ideas behind Faraday cages. Franklin, of course, spent part of his illustrious career flying kites in thunderstorms in attempts to attract lightning and thus was already somewhat acquainted with the vagaries and concepts of electricity.

In 1755, Franklin began toying with electricity in new ways. He electrified a silver pint can and lowered an uncharged cork ball attached to a non-conductive silk thread into it. He lowered the ball until it touched the bottom of the can and observed that the ball wasn't attracted to the interior sides of the can. Yet when Franklin withdrew the cork ball and dangled it near the electrified can's exterior, the ball was immediately drawn to the can's surface.

Franklin was mystified by the interplay of electricity and the charged and uncharged objects. He admitted as much in a letter to a colleague: "You require the reason; I do not know it. Perhaps you may discover it, and then you will be so good as to communicate it to me."

Decades later, an English physicist and chemist named Michael Faraday made other pertinent observations -- namely, he realized that an electrical **conductor** (such as a metal cage), when charged, exhibited that charge only on its surface. It had no effect on the interior of the conductor.

Faraday reaffirmed this observation by lining a room with metal foil and then charging the foil with the use of an electrostatic generator. He placed an **electroscope** (a device that detects electrical charges) inside the room, and, as he anticipated, the scope indicated that there was no charge within the room. The charge just moved along the surface of the foil and didn't penetrate the room at all.

Faraday further examined this phenomenon with his famous ice pail experiment. In this test, he basically duplicated Franklin's idea by lowering a charged brass ball into a metal cup. As expected, his results were the same as Franklin's.

This concept has all sorts of amazing applications, but here's one that's relevant to anyone who's ever been in an airplane. Imagine flying in an airplane that's suddenly struck by lightning. This isn't a rare occurrence -- it actually happens regularly, yet the plane and its passengers aren't affected. That's because the aluminum hull of the plane creates a Faraday cage. The charge from the lightning can pass harmlessly over the surface of the plane without damaging the equipment or people inside.

It's not shocking, really. It's just science. On the next page, you'll see how this clever kind of cage design really works.

Not What Michael Had in Mind

When Faraday built his first cage, he probably didn't have thievery on the brain. But cops often catch shoplifters lining bags with aluminum foil, which interferes with the antitheft RFID tags affixed to pricey products in retail stores.

Electrostatic for the People

In order to understand how Faraday cages work, you need a basic understanding of how electricity operates in conductors. The process is simple: Metal objects, such as an aluminum mesh, are conductors, and have **electrons** (negatively charged particles) that move around in them. When no electrical charge is present, the conductor has roughly the same number of commingling positive and negative particles.

If an external object with an electrical charge approaches the conductor, the positive and negative particles separate. Electrons with a charge opposite that of the external charge are drawn to that external object. Electrons with the same charge as the external object are repelled and move away from that object. This redistribution of charges is called **electrostatic induction**.

With the external charged object present, the positive and negative particles wind up on opposite sides of the conductor. The result is an opposing electric field that cancels out the field of the external object's charge inside the metal conductor. The net electric charge inside the aluminum mesh, then, is zero.

And here's the real kicker. Although there's no charge inside the conductor, the opposing electric field does have an important effect-- it shields the interior from exterior static electric charges and also from electromagnetic radiation, like radio waves and microwaves. Therein lies the true value of Faraday cages.

The effectiveness of this shielding varies depending on the cage's construction. Variations in the conductivity of different metals, such as copper or aluminum, affect the cage's function. The size of the holes in the screen or mesh also changes the cage's capabilities and can be adjusted depending on the frequency and wavelength of the electromagnetic radiation you want to exclude from the interior of the cage.

Faraday cages sometimes go by other names. They can be called **Faraday shields**, **RF** (**radio frequency**) **cages**, or **EMF** (**electromotive force**) **cages**.

No matter what you call them, Faraday cages are most often used in scientific labs, either in experiments or in product development. On the next page, you'll discover exactly how engineers put these ingenious shields to the test.

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Cutting-edge Cages

Swing by a hospital and you'll find Faraday cages in the form of **MRI (magnetic resonance scanning)** rooms. MRI scans rely on powerful magnetic fields to create medically useful scans of the human body. MRI rooms must be shielded to prevent stray electromagnetic fields from affecting a patient's diagnostic images.

There are plenty of political and military uses for Faraday cages, too. Politicians may opt to discuss sensitive matters only in shielded rooms that can block out eavesdropping technologies. All modern armed forces depend on electronics for communications and weapons systems, but there's a catch --these systems are vulnerable to aggressive **EMPs** (**electromagnetic pulses**), which can be a result of a solar storm or even man-made EMP attacks. To safeguard critical systems, militaries sometimes use shielded bunkers and vehicles.

It's for this same reason that Faraday cages are a fond subject in the survivalist subculture. These people, who preach self-sufficiency and mistrust of governmental response in the face of human-caused or natural disasters, believe in shielding all important electronics using homemade Faraday cages. In the event that an apocalyptic cataclysm strikes, they'll still have their shortwave radios and other high-tech tools that could be lifesavers.

Even if you're not particularly concerned with doomsday scenarios, Faraday cages likely play a role in your life every day. These cages harness a basic principle of physics and help people all over the planet put those principles to use -- for safety, luxury, convenience and to help further evermore exciting technological advances.

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