Why do we call it a...Coulomb?

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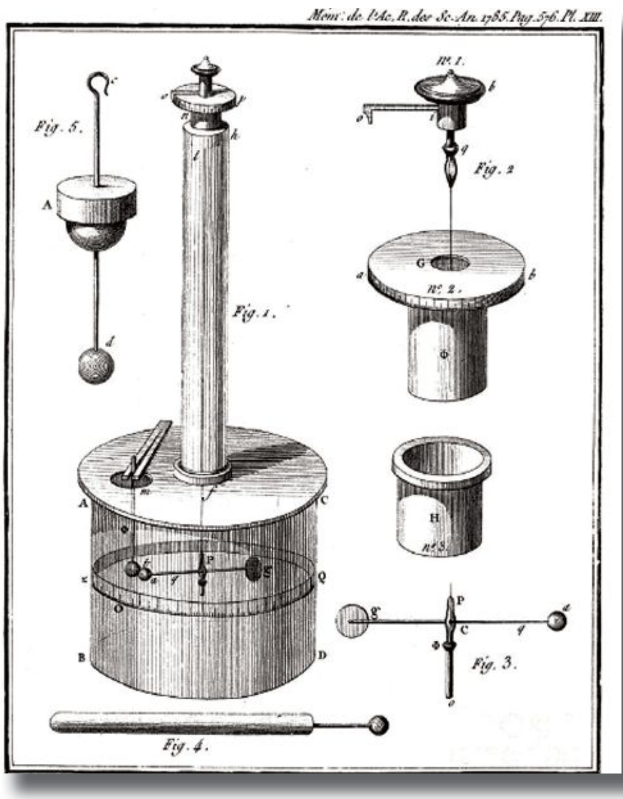
> This is the fourth in a series of articles that explore the history of science and engineering. One way in which this history has been preserved is in the names of the scientific units that we commonly use. Those units will serve as starting points for these articles as we explore "Why do we call it a…?"

In the process of understanding, describing, and measuring the phenomena of electricity, the most commonly encountered units are the volt and the ampere. Note what they have in common. A volt is the measure of electric potential and is best defined by the statement that it takes one joule of energy to move one coulomb of charge through a potential difference of one volt. An ampere is the measure of electric current, with one ampere defined as the flow of one coulomb per second. The common element in those definitions is the coulomb, which is the unit we use to measure the quantity of electric charge. So, how do we define a coulomb? Since this article isn't intended as a dissertation on the derivation of units, we will skip the technical definition and simply say that one coulomb of charge is equal to the charge of 6.242×10^{18} protons. That's a batch. But, what we want to know is why it is called a coulomb.

Like many units, the coulomb is named for an individual, in this case, Charles-Augustin Coulomb who was born in 1736 and died in 1806. Coulomb was a French engineer (engineer, mind you) who, in mid-career, became interested in basic science and made several important contributions in various fields. He was born on June 14, 1736, in Angoulême, a small city in southwestern France, but lived much of his early life in Paris. As was often the case with our scientific forebears, he was born into a wealthy family that could support his education in the classic subjects of language, literature, and philosophy as well as astronomy, mathematics, and chemistry. When his father developed some financial problems, Coulomb left Paris, moving to Montpellier where his interest in science continued to develop.



Coulomb's torsion balance.

Competitive Examination

At this point, Coulomb made a decision that readers of *The Bent* will probably agree demonstrates how smart he was; he decided to become an engineer. After boning up on his mathematics, he took a competitive examination and, in 1760, was admitted to École du Génie, the new (1758) French college of engineering. (I must pause here and point out that "génie" is the French word for genius and is the root of "ingénieur," the French word for engineer. I pause humbly, of course.)

Some 18 months later, Coulomb graduated as a full-fledged military engineer and was commissioned a lieutenant in the French Army Corps of Engineers. For the next twenty years, he did some very serious engineering in the French colonies of the West Indies as well as in France. The kind of work he did—building forts, port facilities, etc.—would be called civil engineering today. Around 1780, he became more interested in fundamental science and began to publish articles about his original research, including a basic model of friction that is still called coulomb friction. He also became interested in electricity and magnetism and published several papers that contributed significantly to the understanding of those phenomena.

I remind the reader that in 1780 electricity meant static electricity. The voltaic pile—what we would call a bat-

Charles-Augustin Coulomb, painted in 1794 as a lieutenant general of engineers by Louis Hierle.

tery—would not be invented for another twenty years, so there was no source of electric current. Indeed, the very concept of current didn't exist. Static electricity, however, had been studied extensively. It was well known that when certain materials were rubbed with certain other materials, they would attract or sometimes repel small objects and could also produce spectacular—and painful—discharges. However, very little had been done about quantifying this phenomenon through measurement and mathematical analysis. If someone wanted to make measurements, they first had to invent and build the instruments to do so. It is here that Coulomb made his contribution to electrical science.

One instrument he built was based on the principle of the torsion balance. If torque is applied to a filament—a thread, a wire, or a rod—the filament will twist by an angle that is linearly proportional to the torque applied. If the filament is long and its diameter is small, a significant twist will be produced by a very small torque which can be created by a very small force acting on a lever arm. Coulomb used this simple but useful concept to build an extremely sensitive instrument for measuring minuscule forces such as the forces of electrostatic attraction and repulsion.

Coulomb's torsion balance is shown in the accompanying figure. The crossbar at the bottom of the filament has a foil-covered pith ball at one end and a combination counterweight/damping vane at the other. An identical ball is given a charge from an electrostatic generator and then lowered through the hole in the top of the test chamber. When the charged ball touches the one on the crossbar, the two balls share the charge equally and then repel each other, causing the crossbar to rotate and twist the filament. By turning the knob at the top of the filament, the crossbar is brought back to its original position and the twist that was required is a measure of the repulsive force between the two charged bodies.

It is left as an exercise for the reader (where have you heard that one before?) to devise other experiments that could be conducted using the electrostatic torsion balance. Through these experiments, Coulomb was able to demonstrate that the repulsive force is proportional to the magnitude of the charges on the two pith balls. He was also intrigued with the recent discovery by Sir Isaac Newton (who will be the subject of a future article) that the force of gravity is inversely proportional to the square of the distance separating two bodies. Could the same be true for electrostatic forces? Coulomb demonstrated that it was indeed true and that the equation describing electrostatic attraction and repulsion—now known as Coulomb's Law—is of the same form as the one describing gravitational attraction.

More Complicated

However, Coulomb didn't stop with his characterization of attraction and repulsion of electric charges. Using his torsion balance and the same techniques, he also demonstrated that magnetic phenomena followed the same inverse square law as gravity and electricity. This was more complicated, of course, because magnetic monopoles (probably) do not exist. So, he used long thin magnets and assumed there was an effective monopole near the end of the magnet. Since the other effective monopole was at the other end of the long magnet, it had a minimal effect on the experiment. The existence of the Earth's magnetic field was also a complicating factor and he had to devise ways to nullify its effect.

Charles-Augustin Coulomb was the quintessential engineer/scientist. He used engineering principles to design scientific instruments and then used those instruments to satisfy his scientific curiosity about electrostatic phenomena. More than anyone else, he explored, learned about, and described the behavior of electric charge. And that's why we call a coulomb a coulomb.

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