Timeless machine detects electric charge

A 200-year-old scientific instrument is new again. Unlike its classic counterpart, however, the modern version can only be seen under a microscope.

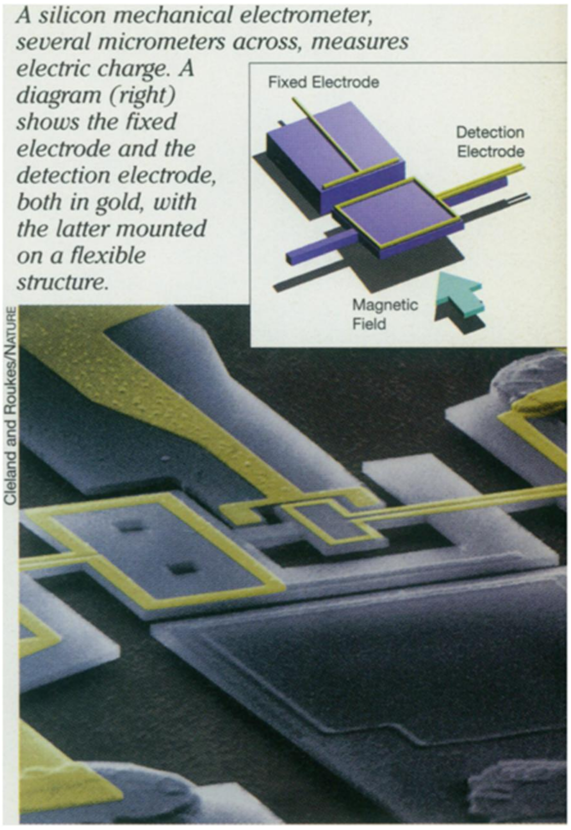
In 1784, French physicist Charles-Augustin de Coulomb developed the torsion-balance electrometer, a sensitive device that measures electric forces. Now, researchers have scaled Coulomb's invention down to just a few micrometers in size. Andrew L. Cleland of the University of California, Santa Barbara and Michael L. Roukes of the California Institute of Technology in Pasadena fashioned the miniature electrometer out of silicon. They describe it in the March 12 NATURE.

The new device, which moves in response to tiny amounts of electric charge, is "quite similar in principle" to Coulomb's original, says Roukes. When electric charge accumulates in a pair of electrodes—one that is fixed and one that rotates—the electrodes attract and draw closer together. In the silicon electrometer, the movable electrode rests on a paddle attached to a thin, flexible beam that twists and vibrates in response to electric attraction. By applying a magnetic field, the researchers can detect that motion. The vibrating beam cuts through the magnetic field, generating a voltage that is sensed by another electrode in the device.

"This is just the beginning," says Roukes, who sees the electrometer as a demonstration of what an integrated microelectromechanical system can do (SN: 7/26/97, p. 62). Other small-scale charge detection devices that use superconducting materials are much more sensitive, he says, but they operate best at a few thousandths of a degree above absolute zero. The mechanical electrometer can operate at slightly above 4.2 kelvins, the temperature of liquid helium. That's still very cold, but doing experiments above that temperature is "about a factor of 2 easier," says Ted Fulton, a physicist at Lucent Technologies in Murray Hill, N.J. Scientists would eventually like to have probes that work at room temperature.

Tiny electrometers could be used to "pick up electrical field signatures on the surface of a semiconductor," adds Fulton. With such probes, scientists could scan a semiconductor's surface, mapping out the distribution of charges on the material to gain a better understanding of it. With this in mind, he and his colleagues fabricated transistors that can sense individual electrons.

Before it can be used in any kind of scanning instrument, the new electrometer will need to get much smaller, Fulton notes. "Most of the interesting fine detail is very close together" on a semiconductor surface. Roukes expects that the electrometer can be scaled down further to make it more useful and to explore the physical limits of such devices. —*C. Wu*



A silicon mechanical electrometer, several micrometers across, measures electric charge. A diagram (right) shows the fixed electrode and the detection electrode, both in gold, with the latter mounted on a flexible structure.

Cleland and Roukes/NATURE

Nuclear collisions spawn odd fragments

The physics graveyard is strewn with the skeletons of failed theories, unexplained effects, and anomalous particles that briefly capture the research spotlight, then rapidly fade from view. Once in awhile, a new piece of evidence may resuscitate one of these slumbering skeletons.

For Piyare L. Jain of the State University of New York at Buffalo, the quarry is an elusive particle called the anomalon, apparently created in high-energy collisions between heavy atomic nuclei and atoms in a solid target. Accelerator experiments in the 1980s and earlier evidence from cosmic-ray interactions (SN: 10/30/82, p. 284) had suggested that a few nuclear fragments born of a collision seem to decay within an unexpectedly short distance. Physicists postulated the existence of anomalons—which briefly hitch a ride on some fragments and represent an unusual, highly reactive state of nuclear matter—to account for the effect.

Doubt cast on the statistical analysis used to establish the anomalous nuclear effect fueled a controversy, and several subsequent experiments failed to detect any evidence of anomalons (SN: 2/25/84, p. 118). "The size of the effects then reported were just statistical fluctuations at the fringe of detectability," says John O. Rasmussen, now retired from the Lawrence Berkeley (Calif.) National Laboratory.

Interest in the topic quickly died down, and Jain became one of the few physicists who remained convinced that anomalons exist (SN: 6/30/84, p. 405). He argued that it would require a high-energy beam of sufficiently heavy nuclei, aimed at a thin target, to pick up traces of these particles. Such experimental conditions were not available in the mid-1980s.

Now, more than a decade later, Jain and his coworker G. Singh report new observations of the abnormal behavior of nuclear fragments in the March JOURNAL OF PHYSICS G: NUCLEAR AND PARTICLE PHYSICS.

In an experiment performed at the Brookhaven National Laboratory in Upton, N.Y., Jain and Singh looked at the shower of fragments created when gold nuclei traveling at nearly the speed of light collided with the atoms of a combination target and detector consisting of a thin photographic emulsion mounted on glass. By examining tracks made in the emulsion, the scientists observed what they contend is a significant enhancement in the number of secondary interactions that take place within a short distance of the initial collision.

"These events would have been missed if the target had a thickness greater than this travel distance," Jain says. That may account for the failure of electronic detectors, whose targets are typically several centimeters thick, to pick up anomalous effects in previous experiments.

Jain's idea that anomalons are so short-lived that their paths would be extremely short is a promising approach, says William C. McHarris of Michigan State University in East Lansing. "He is absolutely correct that a different type of detector could very easily miss the effect. You can't go blindly from one detection system to another and expect the same result."

However, Jain's analysis of the Brookhaven data has statistical shortcomings, as did the earlier experiments, in dealing with strings of rare events. "I don't think Jain has proved his case," McHarris concludes.

One approach would be to do an enormous number of experiments using emulsion detectors. The problem, says Jain, is that very few researchers nowadays have the requisite experience with emulsions. —*I. Peterson*