SCIENCE NEWS of the week

Tracing Corrosion's Magnetic Field

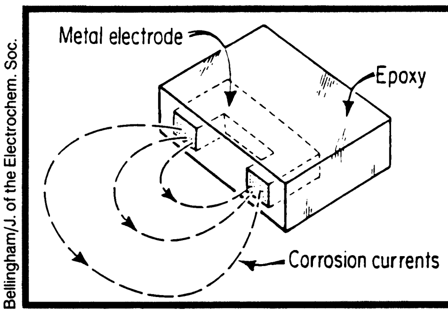
The ravages of corrosion are often clearly visible, whether in the reddish brown flakes clinging to rusted iron or in the mottled green appearance of weathered copper. But the tiny, invisible magnetic fields accompanying the electric currents generated by corrosion-causing chemical reactions have never been observed before. Now, for the first time, a team of researchers has detected those minute magnetic fields.

This finding opens up the possibility of monitoring corrosion where it otherwise may be hidden — inside metal structures like drilling rigs or even within the human body on implants like artificial hips. Moreover, specially designed instruments for measuring magnetic fields may eventually be sensitive enough to detect the onset of corrosion before there are any obvious visible signs.

These new laboratory measurements are the work of graduate student James G. Bellingham and physicist Margaret L.A. MacVicar of the Massachusetts Institute of Technology (MIT), and several colleagues. "The method of measurement requires no electrical connections and provides a remote means for the investigation of electrochemical reactions," they report in this month's JOURNAL OF THE ELECTROCHEMICAL SOCIETY.

In their experiments, the researchers tested a variety of metal samples, such as zinc and aluminum, immersed in hydrochloric acid or in a salt solution. The metals were encased in epoxy, which was then cut away to expose only one or two carefully defined metal surfaces (see diagram). The magnetic field measurements were done with a SQUID (superconducting quantum interference device) magnetometer.

"We weren't sure if we were going to measure anything," says MIT corrosion specialist Peter C. Searson, who helped design the electrochemical cells. Some scientists had predicted that any currents present in such cells would cancel each other out and generate no net magnetic field.



Bellingham/J. of the Electrochem. Soc.

With the magnetometer about an inch above a typical electrochemical cell, the researchers detected magnetic fields as large as 10^{-5} gauss, depending on the metal-solution combination. In contrast, the earth's magnetic field is about 10,000 times larger. Nevertheless, the SQUID magnetometer was able to pick out the electrochemical magnetic signal without requiring special shielding.

"We expected it to be a little harder than that to measure," says MacVicar. But the geometry of the cell arrangement nicely exploited the SQUID's capabilities, she says. "[The magnetometer] is quite sensitive to near things, and it's not affected as much by more distant, noisy sources."

One interesting and surprising property of electrochemical cells was discovered by accident. Normally, the magnetometer scans each cell as the cell moves horizontally beneath the magnetometer. During one run, the researchers left the cell in a single position for a long time while the magnetometer was still on. After 20 minutes or so, the magnetic field strength began to drop. "It was very dramatic to watch this field collapse," says MacVicar. After about a minute at zero, the magnetic field grew larger again but in the opposite direction.

The researchers discovered that such reversals occur over and over again at irregular intervals. This implies that the corrosion currents responsible for the magnetic field can change direction. A small piece of metal surface seems to be able to switch polarity and behave as either a cathode or an anode while corrosion occurs.

The researchers are also beginning to analyze the magnetic signal itself in more detail. They see small fluctuations, which may be related to how quickly corrosion reactions occur or which materials are involved. These observations suggest that remote magnetic field measurements may show not only that corrosion is occurring but also the object's composition.

"The work's all at a fairly preliminary stage," says Bellingham. "We haven't really learned anything new about corrosion yet. But we're coming up with more ideas all the time."

Says MacVicar, "This is the sort of thing that, six months from now, a lot of people will be doing." — *I. Peterson*

Endorphins: A role in heart disease?

For more than a decade scientists have known that the body can manufacture morphine-like natural opiates, known as endorphins. Often released in times of stress, these chemicals can temporarily dull one's sensitivity to pain. But George K.W. Yim and his colleagues at Purdue University in West Lafayette, Ind., appear to have discovered another function — one that seems to chemically link stress and heart disease.

In research involving mice and rats, they have found signs that some as-yet-unidentified endorphin plays an essential role in the buildup of cholesterol in the blood serum of individuals under stress. Such changes typify those that can predispose individuals to atherosclerosis — the development of artery-clogging plaque — according to a report of the work presented last week in Baltimore at a meeting of the American Society for Pharmacology and Experimental Therapeutics.

In one test, the researchers subjected rats over a five-day period to the stress of randomly scheduled restraint in small cages for two to four hours. Compared with unrestrained rats fed the same moderately high-cholesterol diet, the stressed animals developed a near doubling in blood cholesterol levels. There was also at least a doubling of low-density lipoproteins (LDLs) in the blood of these animals and a drop by one-third in high-density lipoproteins (HDLs). Since LDLs are associated with bringing cholesterol into the blood and tissues, and HDLs with removing cholesterol, these are ominous changes, says Henry Bryant, formerly with the Purdue team and now at the Walter Reed Army Medical Research Institute in Washington, D.C.

Rats that were identically stressed after receiving naltrexone — a drug that blocks the effect of endorphins on the brain — developed no cholesterol increase and no change in lipoprotein levels. This ability of naltrexone to prevent the cholesterol-related effects of stress points to the hidden activity of some endorphin, Bryant says.

Further support for an endorphin role was provided in other studies, he says, when morphine drug implants — replacing restraint as a "stress" — yielded virtually identical serum changes in the animals. This externally derived opiate apparently substituted for the body's own in the mediation of serum changes, he says. Like the endorphin effects, morphine's role was blocked by naltrexone.

While these data raise a question of whether addicts might run an elevated risk of atherosclerosis, the researchers note that the poor diet, liver disease and other factors often affecting human opiate abusers would complicate determination of such a risk. — *J. Raloff*