Cold Fusion: End of Act I

The various data quoted as evidence for room-temperature fusion may actually come from two quite different phenomena, but it is likely to be several months before anyone knows for sure

Santa Fe, New Mexico

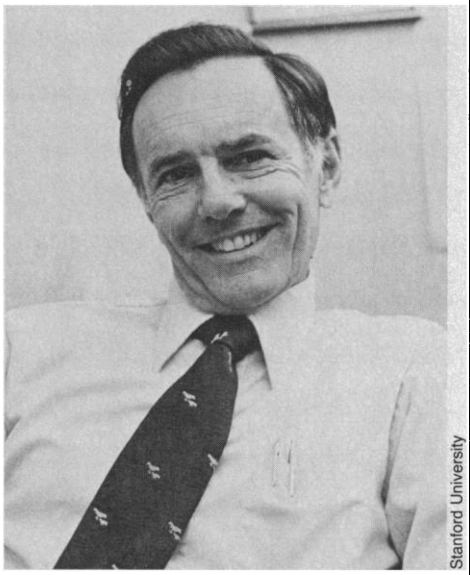
YOU CAN GET UP OUT OF YOUR SEATS NOW, stretch your legs, go get something to drink. It's intermission time in the cold fusion drama.

Last week in Santa Fe, New Mexico, 500 scientists chewed over everything that has been learned about "fusion in a jar" in the 2 months since it was first announced. Their conclusion: "We have reached no consensus," said Norman Hackerman of Rice University, co-chairman of the Workshop on Cold Fusion Phenomena. "Those who didn't believe in the phenomenon have not changed their minds. Those who do believe there is something there haven't changed their minds."

Still, the workshop is likely to be a watershed in the search for cold fusion. Many observers had felt that the claims of cold fusion were dying, and that this meeting would produce an obituary. Instead, several researchers announced new data that bolster the case that something—maybe it is fusion, maybe not—is going on, and much more experimentation will be needed to figure out what. There will be no quick answers. Perhaps the most important scientific result of the meeting was a growing sense that "cold fusion" may actually consist of two unrelated physical processes, and that much of the confusion concerning cold fusion has been caused by assuming the two are the same.

But more than anything else, the workshop showed that cold fusion research is entering a new phase—Act Two, if you will. During the next few months, scientists will take the time to do a careful series of experiments designed more to gather data about the phenomenon than to generate press releases. Several groups who have gotten positive results have agreed to cooperate with other labs—including some of the critics of their results—to try to reproduce and analyze these successes. And if the recommendation of several scientists here is accepted, the federal government will select and fund a few laboratories to serve as centers for exploring cold fusion.

When the workshop opened on 23 May, it had been exactly 2 months since electrochemists Stanley Pons and Martin Fleischmann announced they had achieved room-temperature fusion in electrochemical cells with palladium and platinum electrodes immersed in heavy water. Pons and Fleischmann, who were working at the University of Utah, claimed the cells were producing more heat than could be accounted for by chemical reactions, and that they had observed fusion byproducts—neutrons, helium, and tritium. An electric current in the cells caused the palladium electrode to absorb deuterium (a heavy isotope of hydrogen) from the heavy water, and inside the electrode the deuterium fused, releasing heat, they said.



Robert Huggins *says his cells produce more energy than is put into them.*

Pons and Fleischmann were no-shows at the workshop. James Brophy, vice president for research at the University of Utah, said the two had secluded themselves in their lab and were gathering new data for two papers that will give more details on their work.

After the Utah announcement was made, Brigham Young University physicist Steven Jones revealed that in an independent series of experiments he had detected neutrons coming from electrochemical cells similar to those of Pons and Fleischmann. He detected no heat, however.

The similarity of the experiments and the fact that both sets of researchers were claiming to have seen cold fusion seemed to imply the two groups had discovered the same process. But the accumulated evidence presented at the workshop here indicates the two phenomena are unconnected—experiments tend to show one effect or the other (or neither), but not both. If indeed the two "fusion" phenomena are unrelated, it would be a coincidence of incredible proportion.

Several groups at the meeting reported that they have seen the first phenomenon—excess heat coming from electrochemical cells like those of Pons and Fleischmann. The strongest of these claims comes from Robert Huggins of Stanford University, who says his cells have produced a total power output greater than the total power in. After Nathan Lewis of Caltech and others blasted his experimental procedures at a meeting of the American Physical Society in April, claiming that he had overlooked several possible sources of error, Huggins retook his data with much more stringent controls. The more recent experiments, which were still running at the time of the workshop, continued to show the excess heat, Huggins said.

John Appleby of Texas A&M said his team has run several cells that consistently produce more heat than can be explained by chemical means, although the effect is not as pronounced as the one Huggins claims. A second team at Texas A&M under John Bockris also observed extra heat. Each of the three groups reports excess heat of about the same magnitude as the original Utah announcement.

However, even if the excess heat is a real effect—which many still doubt—it is questionable whether it arises from fusion, since none of the cells that produce extra heat have been shown to contain the normal byproducts of a fusion reaction. Pons and Fleischmann originally claimed to see small amounts of neutrons, tritium, and helium, but they later backed away from the claims and now say they are performing more careful measurements. Huggins said he has not had time to test his cells for fusion byproducts.

The strongest evidence that the excess heat is not produced by fusion comes from

"Don't you remember? We were at Herb and Sally's, and Herb said he knew how to achieve fusion at room temperature, using only gin and vermouth."

Texas A&M. Supramaniam Srinivasan, a member of Appleby's team, said one of his group's heat-producing cells was tested for neutron emission by another group at the university. No neutrons. Two heat-producing electrodes were sent to Rockwell International for tests for helium. No helium. Other cells were tested for tritium. No tritium. "Appleby's results have proved it is a chemical reaction," Lewis commented.

Unfortunately, like almost everything connected with the cold fusion claims, it is not that simple. Bockris's team has seen large amounts of tritium in some of its electrodes, and the presence of tritium was verified by researchers at Los Alamos National Laboratory. Since these results disagree with those of the Appleby group, Bockris said he is looking closely for possible sources of tritium contamination.

Daniele Gozzi of the University of Rome was the only worker to report seeing heat and neutrons simultaneously. He had set up neutron detectors next to an electrochemical cell of the Pons/Fleischmann type. His experiment was not designed to measure heat, but since a few "fusion cells" have exploded, he did have a safety circuit with a thermocouple—if the electrode reached 80°C, the current would be turned off automatically. After the cell had run about 150 hours, the safety circuit switched it off, Gozzi said. His recording devices showed that the temperature of the electrode shot up suddenly to about 150°C, and at the same time the neutron counter recorded 36 neutrons. He saw only one such occurrence, and the data from it do not support fusion as the source of heat, he said—if all the heat had come from the fusion of deuterium atoms, he calculated that he should have detected a billion times more neutrons.

Although there were continuing debates at the workshop about the reliability of the heat measurements, most of the attendees were convinced that the second phenomenon is real—some tiny amount of fusion is going on in deuterium-soaked palladium and titanium. Careful experiments have detected neutrons coming from these metals under various conditions, and nothing besides fusion seems to be a likely explanation.

Kevin Wolf of Texas A&M, who heads up a third cold fusion team at that school, said he has seen neutrons emitted from electrochemical cells similar to those of Pons/Fleischmann and Jones. The neutrons had an energy of 2.5 million electron volts, which indicates they were produced from the fusion of two deuterium atoms, he said. Antonio Bertin of the National Institute for Nuclear Physics in Italy, in a collaboration with Jones, detected neutrons emitted from electrolytic cells that used titanium electrodes instead of palladium.

Somewhat surprisingly, a report from a group at Los Alamos indicates that neutrons can be produced in palladium and titanium without the electric current used in the electrochemical cells. Howard Menlove said his team put titanium into cylinders filled with deuterium gas at pressures from 20 to 50 atmospheres. After cooling the cylinders to 77 K (−196°C) with liquid nitrogen, the group allowed them to warm slowly to room temperature. As the temperature reached about −30°C, Menlove said, he detected bursts of neutrons coming from the cylinders.

The Los Alamos data confirms work reported several weeks ago by researchers at the Frascati Center for Energy Research in Italy. The Frascati report was not widely believed because the idea of fusion taking place in a deuterium-filled metal with no electric current was even harder to swallow than the original Pons/Fleischmann claims.

With the new neutron data, most of the scientists at the workshop were willing to accept the idea of fusion in palladium and titanium and to start looking for an explanation. The favorite in Santa Fe seemed to be that it is not really cold fusion at all. According to this idea, something is creating "hot" conditions—either very high temperatures, or a large electric field, or both—in small regions inside the metal, and this causes the deuterium atoms in the hot regions to fuse.

One way such a hot region could be created would be if small cracks formed inside the metal. Then the stress of the cracking would create heat, and the interior fracturing of the metal could also create intense electric fields.

With the idea of fracture-induced fusion, the scientists at the workshop at least had a testable hypothesis to explain the observed neutron emission. So far, there seems to be no plausible explanation for the excess heat. It seems almost impossible that it could be fusion, because none of the normal fusion byproducts are detectable. On the other hand, the excess heat appears to be more than can be accounted for by any chemical reaction. It is an impasse.

Unfortunately, the two scientists who know the most about the excess heat phenomenon are not sharing that information. Pons and Fleischmann gave out little information in their original published report, and other researchers say they have gotten incomplete and sometime contradictory information from the two. "I don't think they know exactly the conditions [that produce the claimed fusion effect] themselves," said Bockris, a close friend of Fleischmann's. "I think they're playing around trying to reproduce it."

Bockris's explanation of the behavior of the two scientists was more charitable than offered by many of the attendees. Several researchers have said Pons and Fleischmann seem to be withholding vital information about their experiments, apparently in an attempt to delay its reproduction at other labs while they explore their discovery. The insistence of the University of Utah on having lawyers approve everything has also slowed down the exchange of information, putting a planned collaboration with Los Alamos National Laboratory on hold for several weeks, for example.

The next several months are likely to be filled with the type of tedious, repetitive research that is necessary to characterize any unknown phenomenon. The first problem to be overcome is that of reproducibility. For whatever reasons, both the neutron emissions and the excess heat are difficult to pin down, and even laboratories that have seen the effects cannot repeat them in every test sample. Once the measurements can be reliably reproduced, then comes the question of which setups work and which do not. Appleby's team from Texas A&M, for instance, reports that when they replace lithium in their heavy water solution with sodium, the excess heat disappears. Is the lithium essential to the experiment? If so, why?

In short, Act Two will not be nearly so exciting to read about in the papers, but it is where the real science will take place.

■ ROBERT POOL