Three Decades of Cold Fusion Prior to Pons and Fleischmann

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We concur with Chubb[1] when he attributes the cold fusion furor in large measure to language. Pons and Fleischmann must bear some of the responsibility for not knowing that cold fusion was actually discovered in the years between 1955 and 1958 in the Berkeley and Harwell laboratories. Both laboratories made it very clear that the neutrons which they detected were fusion ashes and could not possibly have been produced by thermal collisions. Thermal action creates disorder. What was discovered in the 1950s was that the neutrons all flew in the same direction. If the experiments had generated high temperatures, below the fusion threshold, this would have been a hindrance to any ordered forces which tried to bring about nuclear collisions. Hence one could have called it cold fusion. These facts are well-documented, not disputed, easily confirmed by reproducible experiments, and they were funded by two governments.

In 1958 a team of fusion researchers under Baker,[2] at the Berkeley Radiation Laboratory, reported neutron production in electromagnetically pinched deuterium gas. It turned out to be the first major disclosure of non-thermal fusion reactions. The research was performed within the U.S. program of controlled fusion, code named "Project Sherwood,"[3] and funded by the United States Atomic Energy Commission. Declassification of this project in 1958 led to the paper by Baker and his colleagues. Large numbers of neutrons, representing nuclear ashes, had been detected in deuterium pinch experiments as early as 1955. Electricity generation by neutron heating of water and steam generation seemed to be around the corner. The Berkeley experiment was simple and did not involve complex and expensive apparatus. Progress apparently was as fast as it had been in nuclear bomb research. But by 1958 the nuclear physicists had discovered that the crucial reactions must have been cold fusion and this was deemed to be a great disappointment for, it was thought, a continuously functioning nuclear reactor would have to start "burning" spontaneously once it was "ignited." This was only possible with hot fusion.

The members of the Sherwood project went to great length to prove that the neutrons could not have been created by thermonuclear reactions. They listed no less than ten different reasons, presumably in decreasing order of importance. The first evidence for cold fusion was cited to be, primarily, the axial expulsion of neutrons from the pinch column. Thermonuclear collisions are known to produce an isotropic distribution of expelled neutrons because of the random thermal motions of the deuterons.

The second stated indication of non-thermal fusion was that neutron production was quenched by the application of a weak axial magnetic field (50 - 100 gauss), implying that collisions were dominated by electromagnetic rather than thermal forces. The third point was that the neutron yield did not rise when the applied voltage was increased. The list continued, concluding with reason ten, which was that neutrons were produced at points all along the pinch column, proving that they were not created by the voltage across the full length of the tube.

Bishop,[3] chief of Project Sherwood, summarized the results of pinch tube experiments as follows:

> Two bits of evidence were accumulated that could not be reconciled with the theory of thermonuclear origin. In the first place, the number of neutrons observed was too great, under the operating conditions of the experiments; the temperatures predicted from the Rosenbluth theory were too low to produce so many neutrons from fusion reactions. The second and even more convincing evidence was the result of a careful study of the energy spectrum of the neutrons which were emitted. This study, carried out initially at UCRL, Berkeley, showed that while the neutrons were coming from the body of the discharge, the deuterons responsible for their production (through D-D reactions) were unquestionably moving with rather high velocities in the *axial* direction. The deuterons, therefore, did not have random velocities, as required for true thermonuclear conditions. Instead, they had somehow acquired axial velocities greater than they would have achieved by being accelerated the entire length of the tube! For example, with only 20 kV applied across the tube, the deuterons responsible for producing the neutrons were found to have an average energy of the order of 50 kV.

At the same time, toroidal pinch experiments were performed in Britain with a machine called ZETA. Like the linear pinch tubes in Berkeley, ZETA also generated large numbers of neutrons, which were immediately hailed as a success in controlled fusion. In April 1958,[4] the British scientists admitted that their neutrons were not of thermonuclear origin.

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It is a puzzle why the experts treated the cold fusion findings as a disappointment, because, as we now know, the temperature requirements of hot fusion are very difficult to satisfy. Somehow it was argued that sustained fusion power generation would require a nuclear "burn" once it was "ignited." The axial emission of neutrons from the pinch column required axial acceleration of the deuterons, and increased voltages between the electrodes were tried, but they did not improve the neutron yield. The application of an axial magnetic field did stop the fusion reactions, and this should have been the clue to what was driving the deuterons. Later this led us to propose that the deuteron ions were accelerated by longitudinal magnetic Ampere forces.[5] We called it filament fusion. Unlike the term cold fusion, it stirred no interest in the subject. Longitudinal Ampere forces were unknown to fusion researchers in the 1950s.

Nevertheless, cold fusion research continued with large pulses of current through pinched deuterium gas (plasma focus fusion),[6] heavy water filaments (capillary fusion),[7] and solid deuterium filaments.[8] Government funding was made available for this purpose in the United States, Britain, Germany, and Italy. The collective cost is not known, but it could have been as high as $100 million. This widely published research was dropped only a few years ago in the United States and in Britain, under budgetary pressure exerted by the hot fusion community.

Shortly after the publication of our *Physics Letters A*[5] paper on the role of Ampere forces in nuclear fusion, Chappell Brown[9] reviewed our speculations in 1992. He solicited the opinions of two prominent fusion researchers. One was Professor Haines of Imperial College, London, and the other was Anthony Robson of the Naval Research Laboratory, Washington, D.C. Both were responsible for experimental investigations of fusion reactions produced by current pulses through about 10 cm-long pieces of what Brown called frozen deuterium wires. We argued, as Lochte-Holtgreven[7] did, that what explodes ordinary copper wires into many short pieces[10] also produces the deuteron collisions.

Haines and Robson admitted that their deuterium wires broke up into short pieces and the neutrons could not have been the result of thermonuclear reactions. They estimated that the temperature might have been of the order of one million degrees whereas hot fusion requires at least 100 million degrees.

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About the Authors

Interspersed with industrial research on novel power lines, Dr. Peter Graneau devoted thirty years of his career to fundamental issues of electromagnetism and inertia. Many of his critical experiments were carried out at the Massachusetts Institute of Technology. He published some one hundred papers in physics and engineering journals which were summarized in four books.

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