# A Novel Apparatus to Investigate the Possibility of Plasma-Assisted Cold Fusion

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# A NOVEL APPARATUS TO INVESTIGATE THE POSSIBILITY OF PLASMA-ASSISTED COLD FUSION

COLD FUSION

TECHNICAL NOTE

**KEYWORDS:** *plasma discharge, cold fusion*

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*Cold fusion of deuterium in a transition metal may have been demonstrated recently. These experiments use electrochemical hydrolysis of heavy water to provide the fuel source and conditions for fusion. An alternate approach with some advantages over electrolysis is described. A dc plasma discharge is made in a deuterium gas with a negative electrode made of palladium. Independent pressure, temperature, and current control are also possible in this method. Detection of reactions is achieved by a charged-particle detector placed close to the back side of the cathode. To date, no fusion events have been seen. However, only a small portion of the available parameter space has been investigated.*

## INTRODUCTION

Jones et al.[1] at Brigham Young University described a neutron signal attributable to cold fusion in an electrode of an electrochemical hydrolysis experiment involving heavy water and other electrolytes. Fleischmann and Pons[2] at the University of Utah described heat generation in a similar electrochemical hydrolysis setup that used a palladium rod as one of the electrodes. They ascribed the heat generation to nuclear fusion.[2] Both of these experiments are chemistry experiments using heavy water as the source of deuterium and hydrolysis as the method for injecting deuterium into the electrodes. This paper describes an alternate approach using deuterium gas and a deuterium plasma as a method for injection into the electrode. In this apparatus, electrode temperature, electrical current, and gas pressure can be controlled independently. In addition, heavy charged fusion products can be detected (if they exist) through the use of a surface-barrier detector a few millimetres from the back side of the cathode.

Cold fusion is a method of producing nuclear fusion reactions in a metal lattice. Normally, this is prevented by the coulomb repulsion barrier. Some combination of external electric current, saturation of the metal by the fuel, phase change of the deuterium in the metal lattice, and possible other factors may conspire to reduce this barrier enough to allow fusion events to proceed at a detectable, and perhaps useful, rate through quantum mechanical tunneling.

Electrochemical experiments are plagued with fusion detection difficulties. A great quantity of $D_2$ and $O_2$ gas is released. The potential chemical energy must be accounted for in determining the energy balance. If some surface recombination occurs, the electrodes can get very hot. Temperature measurements in the electrolyte must be made at many places, and the solution should be stirred to ensure thermal equilibrium. Further, the charged fusion products (3-MeV protons and 1-MeV triton, or 0.8-MeV $^3He$) cannot be seen because their range in solids and liquids is <0.1 mm. Neutron detection is possible, but is much more difficult than detecting charged particles. Typically, much more care is needed when determining background.

## APPARATUS

Figure 1 shows a schematic of the plasma discharge device. It consists of two glass pressure vessels of 18- and 5-cm diameters, one inside the other. The pressure in the two chambers can be controlled independently and can range from 5 mTorr to slightly above atmosphere. The vessels are pumped by a mechanical roughing pump and sealed with O-rings, Dow-Corning silicone vacuum grease, and Vac Seal High-Vac Leak-Seal®. The deuterium gas used in both chambers comes from the same bottle and is 99.9% pure.

A plasma is formed in the inner chamber between two palladium electrodes by a dc current/voltage-limited power supply. A 30-W, 500-Ω resistor is added in series to stabilize the discharge from arcing. The anode is a 1-mm-thick, 5- × 10-mm tab of palladium spot-welded to a tungsten wire. The anode tab is placed with the edge facing the cathode and ~3 cm away. The cathode is a 0.2-mm-thick, 1-cm-diam palladium hemisphere formed from a 1-mm-thick palladium sheet. It is silver-soldered to the edges of a hole in a copper backing plate. A quartz disk with a 0.9-cm hole in its center sits against the copper plate on the inside of the inner chamber to protect the copper plate and silver solder from plasma bombardment. Care was taken to keep the silver solder from wetting the palladium surface. Though no silver covered the electrode surface, an oxide may have formed due to the heating. After construction, the palladium electrode was cleaned and polished by an alumina grinding wheel and a stainless steel brush.

A single-turn copper cooling line is soldered to the copper backing plate. Liquid $N_2$, cold water, or hot water can

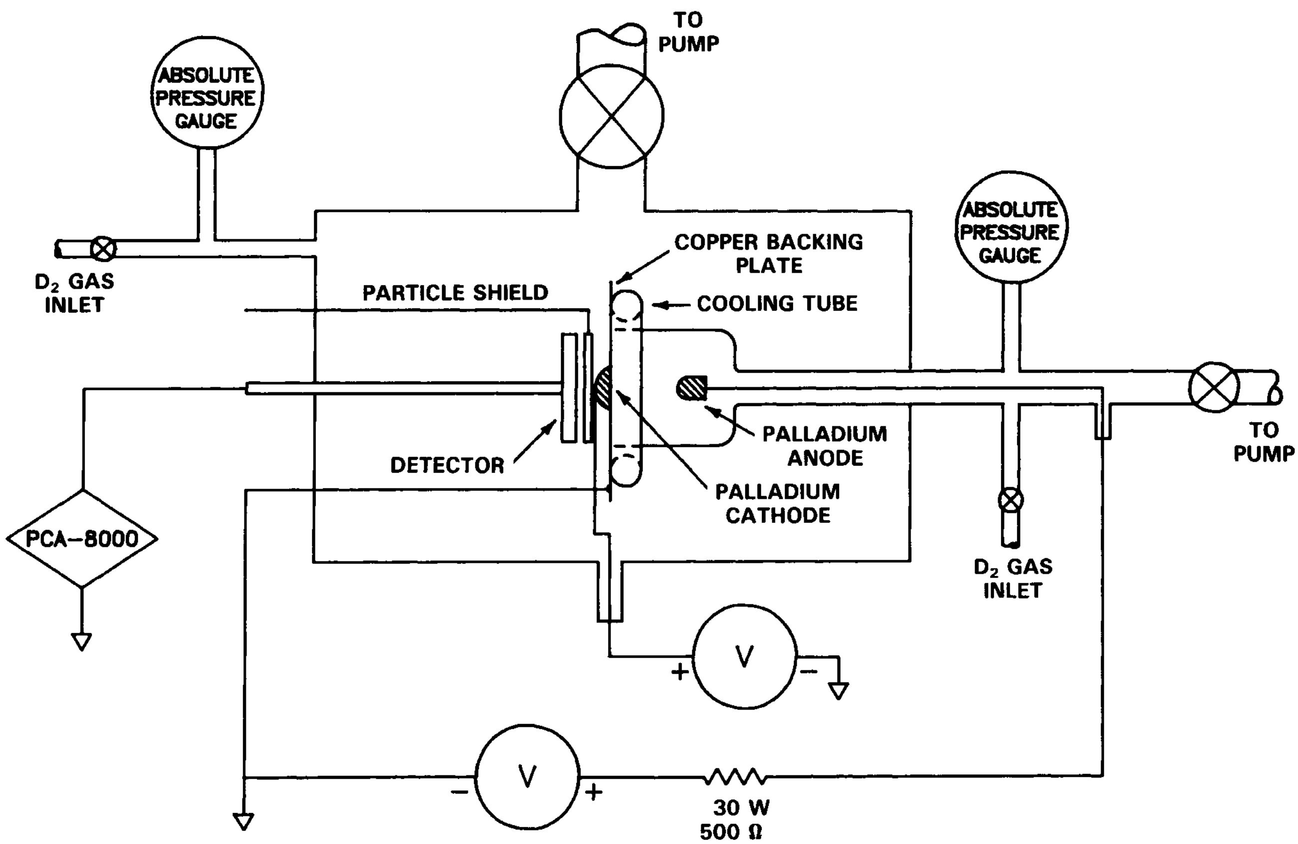


Fig. 1. Schematic of plasma-discharge-assisted cold fusion apparatus.

be forced through the line, giving a nominal temperature range of 77 to 373 K for the cathode.

An additional high-current, low-voltage dc supply is connected through a tungsten wire spot-welded to the center of the cathode. The resistance to ground depends on the temperature and deuterium content of the cathode, but is generally <1 Ω. This supply allows an independent current to flow in the palladium.

Detection of possible fusion products is accomplished by an Ortec Series R™ surface-barrier detector placed inside the outer nonplasma chamber a few millimetres away from the back of the electrode. A rotatable, 2-mm-thick, clear plastic shield can fit between the detector and the cathode. In Fig. 1, it is shown covering the detector. When the shield is in place, it does not contact the detector or the electrode. The detector is connected to a preamplifier, amplifier, oscilloscope, and a personal-computer-based data collection system.

## EXPERIMENT

There is a wide range of operating parameters available to this experiment. Typical operation is to purge both chambers several times with $D_2$ gas, and then fill the inner chamber to 10 Torr and the outer chamber to 300 Torr. The high-voltage supply is then turned up to ~1400 V and breakdown occurs. The voltage immediately reduces to 450 to 650 V and a current of 10 to 80 mA flows through the discharge. For the first few hours, there is a steady decrease in the pressure in the inner chamber. The palladium electrode absorbs deuterium not just from the plasma bombardment of ~400-eV deuterium ions, but also from the gas present on its surface. Plasma bombardment may hasten this interaction through an increase of the surface temperature leading to a higher dissociation rate.

If a higher plasma current is used, an occasional arc develops across the discharge. When liquid $N_2$ cooling is employed, the discharge can be run at higher currents, for example, 50 to 100 mA, depending on pressure, with no arcs developing. The addition of an auxiliary current of a few amperes has no effect on the plasma.

The detector was calibrated with a $^{235}U$ alpha source under vacuum, and the gain was set to show 3-MeV particles in the middle of the spectrum. Background noise increases slightly when the plasma is on, but even the noise from arcs appears at sufficiently low peak height that any particle with energy >300 keV should be easily seen.

To date, no signal above the noise has been seen.

If a signal is seen above the noise, a clear plastic shutter can be introduced between the electrode and the detector. A thick, transparent, nonconducting shield is used so that electronic or light-induced noise would *not* be blocked by the insertion of the shield, but energetic particles would be stopped. Though some low-energy electromagnetic radiations would be stopped by the plastic as well, it is very unlikely that they could produce a signal in the detector in the first place.

In addition to the surface-barrier detector, a standard $BF_3$ neutron detector and Geiger counter are placed within 30 cm of the cathode. Though their sensitivity is much lower than that of the surface-barrier detector, copious neutron or gamma production could still be seen if it existed. Only signals due to electrical interference from the plasma have been seen in the neutron detector. The false reading was ascertained by moving the experiment to one side of a double-screen copper-shielded room (Faraday cage) and placing the neutron detector inside of the shield room. When the detector was placed inside the screen room, the signal disappeared. The plasma-induced noise on the neutron detector could also be reproduced by an air plasma.

## DISCUSSION

The detection scheme used supposes two things: (a) The deuterium-deuterium fusion reaction proceeds along the known proton-triton or $^3$He-neutron branches, and (b) the fusion reactions take place near the back surface of the 0.2-mm-thick electrode. (The range of a 3-MeV proton in palladium is only 0.025 mm, and the ranges of the $^3$He and triton are even smaller. The range of the fusion products in a few hundred Torr of $D_2$ is on the order of centimetres.)

We have only explored a small fraction of the available operating space afforded by this apparatus. It may be possible to effect a phase change of the deuterium location in the metal by quickly changing the pressure and temperature of the electrode. The phase change may set up conditions that could allow fusion. Such experiments are currently under way.

Future work will include varying the external and internal pressures, temperatures, discharge current, and auxiliary current. In addition, a larger inner chamber could be constructed to allow the placement of the surface-barrier detector where it could view the plasma-facing side of the cathode.

## ACKNOWLEDGMENTS

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