Russian cold fusion effort utilizes solid electrolyte

After the success of Fleischmann and Pons, the Russians may have come up with an "encore," according to the weekly of the Ural Bureau of the Russian Academy of Sciences. Carol White reports.

At the Third International Conference on Cold Fusion, held in Nagoya, Japan Oct. 21-25, 1992, Russian scientists reported upon some sensational results, which if corroborated, would imply a leap ahead to practical applications. One researcher, Dr. Yan R. Kucherov, reported on an experiment which he claimed has been repeated 1,000 times, and which he said produced 500% excess power. It is induced in a vacuum chamber, using a thin palladium foil and a gas discharge method of loading; he found a large increase in helium-4 concentration, and detected radiation as well. He believes that his method is an example of cold fission rather than cold fusion.

Another Russian experimental group has pioneered in the development of an entirely new cold fusion material, a tungsten bronze single crystal.

This experiment was reported by Kabir Kaliyev at the Third International Cold Fusion Conference. A crucial feature of the material, is that the tungsten bronze lattices have channels perpendicular to the crystal surface. By evacuating sodium from the original tungsten bronze material, it then becomes possible to gas load these channels with deuterium. Within only ten minutes of loading there is a high neturon flux, and the emission of radiation, along with high excess heat. This experiment, like Kucherov's, is claimed to be highly repeatable.

We are printing a translation of an article in the section "Science of the Urals," which appeared in October 1992, in the weekly newspaper of the Ural Bureau of the Russian Academy of Sciences, headlined "Cold Fusion: Encore of a Sensation." It was given to me by the Russian scientists when I was at Nagoya, and is of interest to our readers, both for its description of the experiment, and also for the commentary on the general situation of Russian science. The editors would like to acknowledge the help of translators Denise Henderson and Rachel Douglas.

Only for specialists in the humanities

It would seem that, while raising the prices for energy sources, the government of Russia has set no price at all for one of them, and it's the most promising one. The enterprising Japanese are scooping it up from us practically for free. What is it? The water of Lake Baikal, which is rich in deuterium.

But let us not despair. The ocean is a gigantic, practically inexhaustible reservoir of this natural fuel. The deuterium component of natural hydrogen is 0.015%. The energy from the merging of deuterium nuclei is ecologically the cleanest source of energy. This is widely known and understood by all. Until now we have obtained energy by breaking bonds established by nature. And when things are broken, burnt, or split—obviously there remain fragments, soot, and dirt, some of it radioactive. In the 21st century (which is not so far off), we will finally stop destroying things in order to get warm. And then, on the one hand, we will solve the problem of fuel resources for energy, and, on the other, the problem of waste.

All that is required for this is to achieve the necessary rate for the reaction in which the deuterium nuclei merge. The traditional path is heating. But up to very high temperatures. The kind of temperatures which to obtain one must, for example, explode an atomic bomb. There is another, peaceful path—the gigantic accelerators known as Tokamaks. According to the most optimistic prognosis, electric power stations based on this principle will come on line in the 2050s-2060s and will be so powerful that they will present us with a new rebus—the problem of energy transport.

But after the announcement made in 1989 by Fleischmann and Pons, about the achievements of cold nuclear fusion in a very simple experiment involving the electrochemical saturation of palladium by deuterium, voices rang out around the world, excitedly and gladly affirming: "It exists! There exists yet another path—unexpected, impossibly paradoxical, and, at the same time, the salvation of mankind!"

What does "cold fusion" mean? It means: The fusion of deuterium nuclei takes place, when a number of relatively easily reproducible parameters are observed, at room temperature, without any epic-scale fundamental research equipment, right there on the table, one could say.

How possible does this look to be? Picture it. Knowing perfectly well, that water in a tea-kettle, if it is placed on ice, will not boil, you and I order a tea-kettle made not of normal metal, but, for example, of bronze. We paint the ice green and for good measure we introduce a constant electrical current from the battery of a pocket flashlight. Having done all this, we repeat the experiment—and the water boils. Is there something to be surprised about? But if we announce to the whole world, that this is not a clever trick, but a unique scientific experiment, opening up serious prospects for boiling water at temperatures close to 0° Celsius; then there's also something to be indignant about.

Yet after the sensation Fleischmann and Pons caused, in hundreds of laboratories thousands of hotheads began the hunt for cold fusion. And the wider public, thanks to the talkative press, experienced a moment of euphoria, which swiftly turned into a disappointed and wry smile.

The problem is, that all the experiments, both those that were conducted in a set-up analogous to the Fleischmann-Pons variant and those done with non-electrochemical methods of hydrogenation (dehydrogenation), were distinguished by the same abominable features: scandalous lack of reproducibility and by failure of the effects significantly to exceed the background or the threshold for a measurable result. (In the idiotic example with the tea-kettle, the latter case can be represented as a pair of accidental bubbles instead of boiling.)

The lightning of the sensations blazed up and went out. Several stubborn scientists still made their way along the path it illuminated. But they had to make their way under a hail of mockery, accusations of ignorance, charlatanry and pseudoscience.

It was most probably with particular joy and deep (remember the 1970s) satisfaction that the representatives of the so-called "tokomafia" buried the reckless idea. These workers on hot nuclear fusion, of course, were far from euphoric. In their eyes, at the least admission of the fantastic possibility of cold fusion, their billions of state subsidies would start to melt one after another. Of course we are talking only about the situation in the U.S.A. Let the American newspapers report on the "tokomafia" in our country.

But the alarm of the thermonuclear scientists turned out to be (or seemed to be?) false. In May 1991, the executive director of the American Physics Society Dr. Robert Park from the pages of the *Washington Post* sounded the following impressive retreat:

"The cold fusion story was not so much a story of bad science, as general human weaknesses like zeal, ambition, vanity. . . . Without a doubt, among the cold fusion researchers there are true believers just as there are sincere scientists who believe in psychokinesis, flying saucers, the creation of the world, and so forth. A degree in science is not an inoculation against stupidity and falseness."

Of course, the honorable executive director was not alone in having such an estimation of the "cold fusioneers," but note that, having obeyed the wish to slander them, he himself then carried out a sort of cold fusion, ascribing to the same enthusiasm—error, zeal, ambition, sincerity, stupidity and falsehood all at the same time! Simply fantastic!

Fortunately, such weaknesses (having long since ceased being universal, it seems) as work for the soul, above plans and for nothing; the ability to pay the machinist out of one's own pocket, for finishing on time a detail, indispensable for an experiment; the ability at times to do without complicated equipment in solving difficult problems; and other such qualities have not yet disappeared in Russia. Moreover, and especially surprising—they have not disappeared among the colleagues of the Ural Bureau of the Russian Academy of Sciences!

And it has been done! No, we'll put it without this biblical categorical tone: and, it would seem, it has been done.

The 70-year-old Jean-Pierre Vigier (true, he doesn't look more than 50, despite his having taken part in the Resistance and in the Vietnam War and on the side of the Vietnamese, at that, against the American aggressors), the famous Jean-Pierre Vigier, who worked with Joliot-Curie and Louis de Broglie, heard about the experiments at our Institute of Electrochemistry, on his stops on his way back home from Donetsk at Yekaterinburg and doesn't regret it. He is present at an experiment, one of the last in a series of more than 100, all of which, every single one, had affirmative results. He observes the effect with his own eyes . . . and jumps with delight, like a boy!

Only for natural scientists

What did happen? What, in fact, occurred?

Instead of an answer—here are the theses from the report of Academician A. N. Baraboshkin and Doctor of Chemical Sciences K. A. Kaliyev, delivered Oct. 5, 1992, at a session of the Presidium of the Ural Bureau of the Russian Academy of Sciences. But first, one more name must be mentioned—that of L.D. Gudrin, chief engineer at an optics factory (in Yekaterinburg), whom Kabir Kaliyev presented to us as his equal colleague, and even, to a significant degree, the initiator of the works, which have already today yielded a convincing result.

> In our opinion, it is precisely the utilization of solid matter, especially in a monocrystallic state, that makes it possible to create the conditions for cold fusion to occur:
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> - to lower the Coulomb barrier (screening of heavy atoms by electrons);
> - to accumulate energy;
> - to use part of the energy of the reactions wherein deuterium nuclei merge for bringing about subsequent acts of fusion.
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> So far, all materials used in cold fusion experiments are substances of deuterium/metal systems. They all possess mixed ion-electron conductivity (with the latter predominant), i. e., (from the standpoint of electrochemistry) they are solid electrolytes with mixed conductivity.
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> Tungsten oxide bronzes (TOBs) are also solid electrolytes with mixed (cation-electron) conductivity. In these substances, a stable sub-lattice is formed by the octahedrons of WO_6, while cations of alkali metals (hydrogen) are displaced into the empty spaces between octahedrons. These spaces form channels, along which the cations can move. Electron conductivity in TOBs is lower than in metal-hydrogen systems. Since we have developed ways to obtain monocrystals of TOBs and their electrochemical interaction with hydrogen electrolytes has been studied, TOBs were used in the cold fusion experiments.
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> A monocrystal of sodium TOB was subjected to anode treatment in a vacuum while being heated, after which it was cooled and put in contact with gaseous deuterium. Neutron production and change in the temperature of the crystal were measured. For comparison, analogous experiments were conducted with light hydrogen.
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> By the end of 1991 the level of qualitative reproducibility was reached, i.e., to achieve neutron production that was statistically significant in excess of the background in the case of deuterium and the absence of this effect for hydrogen. Moreover the effect was correlated (with a precision of up to one minute) from the moment the deuterium was loaded. More than 100 experiments were conducted with affirmative results, which were also observed in the case of repeated utilization of the same crystal. In particular, in the last six experiments on one monocrystal, the output of neutrons in 2 minutes averaged 640±240 at the loading and 560±240 at the subsequent evacuation. In the control experiment, using a highly sensitive neutron detector, provided by the physics department of the Lugansk Machine-Building Institute, a neutron flow of 36,000±13,000 was recorded in the course of 1 minute.

What are tungsten bronzes?

The tungsten bronzes are a very interesting, but little appreciated, family of materials. They are not related to bronze, an alloy of copper and tin, except in coloration. However, the structure of tungsten bronzes are similar to the high-temperature copper oxide superconductors. In fact, the tungsten bronzes were the first oxide superconductors and were the focus of extensive research 10-15 years ago. But by the early 1980s, most of this work had been set aside in favor of other pursuits.

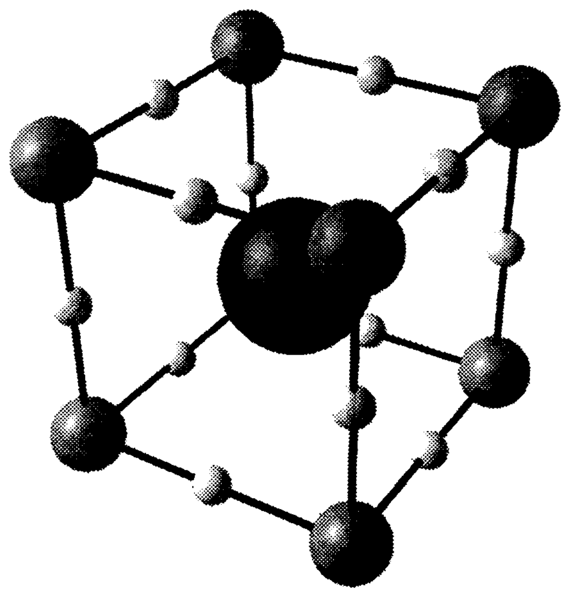
The tungsten bronzes are a group of compounds made up of tungsten trioxide, WO_3, and an alkali metal, such as sodium (Na), potassium (K), rubidium (Rb), or cesium (Cs). The general chemical form is M_xWO_3, where M=Na, K, Rb, or Cs, and $0<x<1$. The color of these compounds varies with composition, at x=0.93 the color is a bronzelike golden-yellow, hence the name; at x=0. 32 the color is a blue-violet. For this reason tungsten bronzes are use as pigments in dyes and paints.

The variation in composition also affects the structure of the compound. Imagine a cube with a tungsten atom at each corner, an oxygen atom in the middle of each edge and an atom of an alkali metal in the center of the cube. However, in a tungsten bronze there is not an atom at the center of every cube. When $x<1$, only a certain fraction of the cubes will contain an alkali atom. If x is large, close to 1, the structure of the crystal lattice will be cubic. As x decreases, and fewer of the cubes are filled, the structure changes. At about x<0.3, or with less than 30% of the cubes full, the structure becomes hexagonal, with atoms arranged in hexagonal plates.

The cubic arrangement described above with an atom in the center of a cube is typical for perovskites, a group of ceramic materials with a variety of interesting electrical properties. The high-temperature superconductors are among these. In the cubic phase, tungsten bronzes are metallic and conduct electricity. However, in the hexagonal phase, they become superconducting. William Moulton, at Florida State University in Tallahassee, has done a lot of work with potassium, rubidium and cesium tungsten bronze superconductors. Dr. Moulton points out that these compounds have large anisotropy, much like the high-temperature superconductors; that is, there are differences in properties depending on the direction of measurement in the crystal. The best of these, a rubidium bronze, had a transition temperature, the temperature at which a material becomes superconducting, of about 6°K.

Iowa State University in Ames was another center for tungsten bronze research. There, Douglas Finnemore studied the effects of pressure on the transition temperature of potassium tungsten bronze. The object was to enhance the interaction between electrons and the lattice vibrations, or phonons. However, these tungsten bronzes were still superconductive at only 4°K.

Howard Shanks, also at Iowa State, was able to produce sodium tungsten bronze compounds that were superconductors at as high as 10°K. Part of his success was due to techniques he developed to grow large crystals of this material, some as large as 3 inches. Dr. Shanks finds it ironic, in light of today's superconductor research, that



one of the reasons why work on tungsten bronze was dropped was because so many saw no future in oxide superconductors.

Other work at Iowa State has included using sodium tungsten bronze as a coating for one of the electrodes in a fuel cell that used hydrogen and oxygen as fuel to produce electricity. The test cell that was built ran for about a year. Another application that was investigated was using tungsten compounds for hydrogen storage. It was found that for H_xWO_3 with x<0.5 hydrogen could move in and out of the material with ease. Some of this work was also done in Germany.—*Mark Wilsey*

After extensive discussion, many questions, doubts, and wishes, the chairman summed up. Academician G.A. Mesyats is not among the hotheads drawn into the race for cold fusion. His opinion on this matter, although it was expressed, of course, in more logical formulations, until quite recently was practically identical with the opinion of Dr. Park. But this time, he, too, surrendered, since a fact obtained by experimentation is something that in science—and, probably not also in science—can break any personal opinion, no matter how indisputable it seemed or how many respected authorities shared it.

Gennadi Andreyevich also was present in the laboratory at the moment, when the counter gave the neutron flow and now, at the presidium, he raised serious doubts about whether one of the participants in the experiments had a concealed source of hidden neutrons in his pocket. There were no suicides! And consequently, one could proceed to the congratulations.

Of course, much remains unclear. First of all, the mechanism of the process has not been studied, although it was successfully modelled and a result was recorded. Great work is before us. The experiment is to be tested in other laboratories, and, probably, in many countries. Experts in nuclear fusion must give it an appraisal. But without a doubt this is a major discovery, and if it is cold fusion, it is the opening of an era.

"Experiment—is the criterion for truth," Kabir Kaliyev in a conversation with us aptly cited Francis Bacon.

"And the means to temper it is a long and expensive practice?" we supplement the well-known formula.

"No, if we procrastinate, and if, as before, there is no money, we will simply be outstripped. We will not manage without serious financing. There must be research on the mechanism involving specialists, not those who will work for nothing, but real experts in each field. We need nuclear physicists, both theoreticians, and experimentalists, and electrophysicists. True, this should belong to the whole world. . . ."

"That's how it is," again we allow ourselves a small supplemental remark. "But perhaps, this neutron flow will awaken the government and the Supreme Soviet which are sleeping and dreaming of the future prosperity of Russia, but in their waking hours finance the academy's science "according to taxes received"?

Today Kabir Kaliyev affirms that he and his colleagues already are on the verge of solving the problem of controlling an open process. He says that, although no one believes it, in two to three years, they will have made a compact reactor. And then it will begin. . . .

For everyone, including children and youths

And now several words in the spirit of Jules Verne, in the spirit of the boldest, most giddy science fiction being brought to life before our eyes.

We obtain, according to estimates made by engineer L.D. Gudrin already in 1989, a surprisingly small 10-kilowatt source of energy which runs on a battery, comparable to pocket flashlight batteries, on 100 ml of heavy water for three years without interruption. Its cost is 270 rubles in 1989 prices. Every consumer of energy, including each of us in our apartments, acquires total autonomy. Electrical transmission lines will be sent off for scrap metal. Electric power stations of all types will be dismantled. Automobiles will run for years without exhaust and refuelling. Electric locomotives without wires will pull trains. The dreams of D.I. Mendeleyev will come true: We will cease "burning assignats [currency]," i.e., the barbaric burning of oil and gas by which, of course, we will improve the condition of the atmosphere and all the whole environment. Global changes will come to pass in world economics and politics. The so-called developing countries, at last, will achieve the level of developed countries. Mankind will unite on the road of creativity and progress.

But perhaps it will not be that way. Why not fantasize with a negative sign? Will the military yet have their say? How about neutron guns, absolutely silent and with splendid sighting qualities—they fire without any recoil?

Kabir Akhtemovich and I are already sorry that we are giving Baikal heavy water to the Japanese for free. What if the 21st century becomes a century of struggle for control over the reserves of this water on a worldwide scale?

But, no, this would be too stupid. Is there really not enough for everyone?

But no small amount of stupidity in history followed along like a stinking, smoky train, behind brilliant explosions of the intellect. So let us live, and we shall see.

The presidium applauded, but so far, only sitting down.

How 'big science' stifles discovery

by Giuliano Preparata

Dr. Preparata is a particle physicist from Italy. Subheads have been added.

On March 10 and 11, two hundred journalists and scientists attended a meeting sponsored by the Alessandro Volta Center, on Communication in Science. The topics under discussion were alleged frauds by a number of people, such as David Baltimore, the former president of Rockefeller University. The greatest fraud of all, the veritable inquisition against cold fusion scientists, was not a subject of discussion until I brought it up during the question period.

One of the featured speakers at the conference was the Englishman John Maddox, who edits *Nature* magazine. He kept his entire presentation on the subject of the today-very-much-in-style (who knows for what reason) scientific frauds, and indicated the ethical-scientific problems which his magazine is called on daily to resolve; but during the public question period, John Maddox was confronted by this writer about an exemplary episode that involved the function of one of today's important scientific institution, namely, *Nature* magazine. Is not the failure of *Nature* magazine to cover any of the positive evidence relating to the phenomena known as cold fusion, a scientific fraud?

My question was related to that chapter of contemporary research which has been given the name of "cold fusion." The reader will certainly know about the hard and hot polemics that have sprung up around this fascinating field of research, but perhaps not everyone will know that at the source of the discrediting of cold fusion, are the unfounded and false accusations, which were, in particular, published immediately in *Nature,* which was not the treatment accorded to the discoverers of cold fusion, Fleischmann and Pons.

Nature featured a refutation of the experiment by a group from the prestigious University of California, Caltech, who were and remain extremely negative with respect to the reality of the phenomena reported by the two electro-chemists from Utah. However, a detailed analysis of the data reported in the Caltech article, a year and a half later, by a group of experts, revealed the presence of grave errors which, were they to be corrected, might render the experiments of Caltech quite completely compatible with those of Fleischmann and Pons.

One year ago, Melvin H. Miles, a reputable electrochemist from the U.S. Navy laboratories in China Lake,