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:

- 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.

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.

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.

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.

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 $36,000 \pm 13,000$ 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.

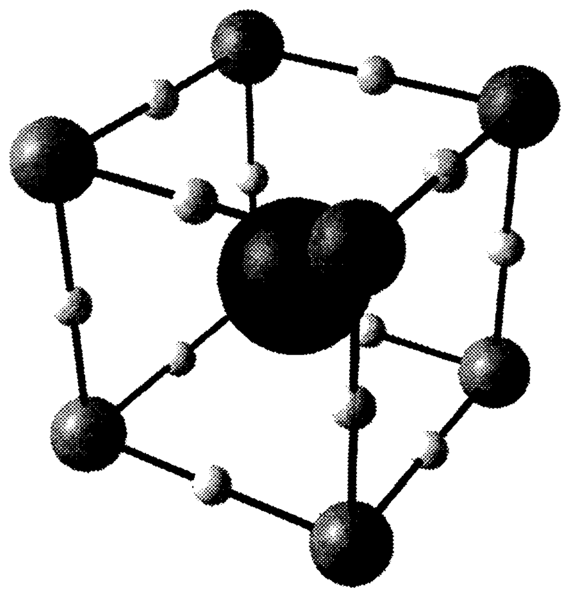
The tungsten bronzes are a group of compounds made up of tungsten trioxide, WO_3, and an alkali metal, such as sodium (Na), potassium (K), rubidium (Rb), or cesium (Cs). The general chemical form is M_xWO_3, where M=Na, K, Rb, or Cs, and $0<x<1$. The color of these compounds varies with composition, 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