First liquid permanent magnet predicted

Magnetic states occur in bulk samples of solid materials when the magnetic moments, or intrinsic magnetic fields, of the atoms line up in orderly patterns. Ferromagnetism is the state in which all the magnetic moments line up in the same direction and cooperate to produce an overall magnetic field.

The fairly rigid arrangement of atoms in a solid is a definite advantage, and, it would seem, virtually a necessary basis for this kind of cooperation. The structure of liquids or gases appears too chaotic for it. Yet there is a liquid that should actually show a ferromagnetic state, according to A. J. Leggett of the University of Sussex in England. It is superfluid liquid helium-3 in the so-called A phase.

Writing in the Dec. 15 NATURE, Leggett points out that it has often been remarked that this phase of superfluid helium-3 possesses "orbital ferromagnetism," but it seems that the term is used metaphorically to refer to the electronic structure of the liquid and not to the existence of any overall magnetism. Leggett proposes that the liquid should be "quite literally ferromagnetic" with a detectable overall magnetism that should have experimental consequences. As such it would be the first natural liquid ferromagnet.

Superfluidity is a property that appears when liquid helium (either 4 or 3) is cooled to within a few degrees of absolute zero. It is a state characterized by a loss of viscosity and rather bizarre behavior. (The liquid flows through orifices that would normally be too small for it; it will climb the walls of its container in seeming defiance of gravity, etc.)

The accepted theory is that superfluidity comes about because the atoms of liquid helium bind themselves into pairs (called Cooper pairs) that travel together. Although the electrons belonging to the two atoms are rotating in opposite directions, they do not quite cancel each other's rotation. The way the electrons arrange themselves leads to a small net orbital angular momentum for the Cooper pair. This orbital angular momentum produces a magnetic moment. In the phase of liquid helium-3 that Leggett is dealing with, all these orbital angular momenta point the same way, so the magnetic moments should add up to an overall magnetism that is tiny but measureable. □

Generating hydrogen in magma deposits

Hydrogen is hardly a household fuel nowadays, but it is clean and efficient and, as fossil fuels are depleted, hydrogen is expected to come into more and more use. Already about 3 trillion cubic feet of hydrogen are used in the United States every year.

A group of physicists and geochemists at the Sandia Laboratories in Albuquerque, C. J. M. Northrup Jr., J. K. Galt, T. M. Gerlach and P. J. Modreski, has developed a method of producing hydrogen that uses water as a source. Because of the earth's huge resources of water, the method has a long-range potential that is virtually endless. Furthermore, it will also produce quantities of carbon monoxide, methane and steam.

The method sounds a bit futuristic but is possible, the Sandia group reports. It consists of reacting water with hot magma in the earth's crust. Ferrous iron contained in the magma would combine with oxygen from the water, and the leftover hydrogen would be freed. Laboratory experiments indicate that the best conditions are obtained by using magma at 1,200° C. This results in the conversion of three mole percent of the injected water to hydrogen. That translates into 500 pounds of hydrogen per hour if 20,000 gallons of water per hour is pumped into the magma body.

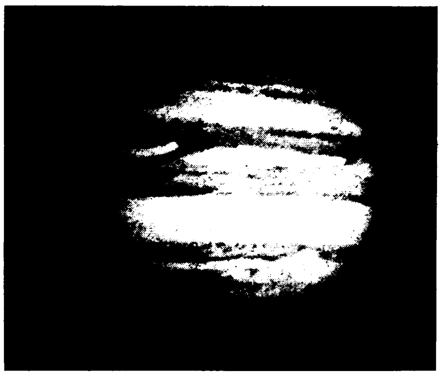
The best magma to use is the basaltic magma under the sea bed, which contains 10 to 12 percent ferrous iron. The magmas usually found under continental landmasses, andesitic and rhyolitic, contain five to seven percent and less than two percent ferrous iron respectively. Ten to 20 holes drilled into a magma with 12 percent ferrous iron could yield 26 billion cubic feet of hydrogen per year.

The hydrogen production can be increased by adding biomass, essentially organic garbage, such as sewage sludge, straw and stalks, bagasse from sugar cane production, or seaweed to the water. Water containing 10 percent biomass injected into a 1,300° magma would yield gases containing 10 percent hydrogen, four percent carbon dioxide, one percent carbon monoxide and a trace of methane. At lower temperatures hydrogen production becomes less efficient. With a 600° magma, methane production would dominate at about three mole percent, with two percent hydrogen and one percent carbon monoxide. Use of cooler magmas would not be practical.

But is it practical at all? The drilling is possible, the Sandia report says, but it is the greatest obstacle. However, there are some magma chambers within two or three kilometers of the ocean bottom. These should be reachable by an extension of present drilling technology.

If the method works out, it will provide a source of hydrogen that will not be tied to the supply of natural gas, from which most hydrogen produced today is made. Hydrogen is an attractive fuel for future use, but the large additional quantities needed for a "hydrogen economy" cannot be made by present methods, Northrup says. □

Rare gas found in Jovian atmosphere



Pioneer 10/NASA

Jupiter: Germane to turbulence.

A rare gas known as "germane," consisting of molecules containing one atom of germanium and four of hydrogen, has been identified in the atmosphere of Jupiter. Besides merely adding to the list of known Jovian components, however, it is said to be another sign of the highly turbulent state of the planet's atmosphere.

The gas was found by Uwe Fink and Harold P. Larson of the University of Arizona's Lunar and Planetary Laboratory and Richard R. Treffers of the Radio Astronomy Laboratory of the University of California at Berkeley. Spectroscopic studies made aboard NASA's Gerard P. Kuiper airborne observatory revealed a concentration of 0.6 parts per billion, an abundance similar to those of minor pollutants in earth's atmosphere. The germane spectra apparently came from a level in the Jovian atmosphere where the temperature was about 300°K (80.6° F), yet, says Fink, it would be expected at temperatures more like 1,000°K (1,340.6° F). The implication is that the substance was formed at greater depths, where such temperatures exist, then transported upward by convection. □

Asbestos: A threat by air or by water

Asbestos in the air is clearly a health problem. It causes both asbestosis, a painful lung disease, and cancer of the lung lining. Last month asbestos workers received more than $5 million in a suit against the government and several private firms. The workers held that negligence resulted in their exposure to asbestos on the job, leading to subsequent health damage.

But what about the effects of asbestos in the water? Those fibrous particles of silica and other elements contaminate many drinking water supplies. Some of the asbestos comes from mining operations, as in Minnesota where Reserve Mining has dumped fibers into Lake Superior. In the San Francisco Bay area, the pollution comes from water running over asbestos-containing rocks. Ingestion of fibers may also result from water pipes made of an asbestos cement or from use of asbestos filters for clarifying beverages.

Studies of industrial workers who are exposed to high levels of asbestos indicate that the fibers may be responsible for cancer outside, as well as in, the lungs. "People who breathe in asbestos, also swallow asbestos," explains Arnold L. Brown of the Mayo Clinic in Rochester, Minn. Inhaled fibers are swallowed as they are cleared from the lungs. Among people occupationally exposed to asbestos, researchers have observed a three- to four-fold increase in gastrointestinal cancers. (The increase in lung cancer is more substantial—20-fold for workers who smoke.) The gastrointestinal cancer evidence is "certainly suggestive," Brown says.

Animal experiments have provided contradictory data on whether asbestos fibers can penetrate the lining of the gut and damage various organs. With scanning electron microscopy, Brown and colleague Alan R. Storeygard have now caught fibers in the act.

The researchers injected a suspension of asbestos fibers into a region of a rat's intestine that had been tied off. The fiber concentration of the suspension was much higher than that in any drinking water supply. After one hour, Storeygard and Brown removed the tied-off section and prepared a sample for microscopy.

Micrographs revealed asbestos fibers impaling cells in samples from three of the five rats exposed to the suspension. No fibers were seen in cells from rats exposed only to a salt solution. A few asbestos fibers were found enmeshed in the layer beneath the intestinal lining cells. This layer is the loading area for ingested material to pass into blood vessels for distribution throughout the body.

Microscopic analysis of composition confirmed that all except one of the identified fibers is asbestos. The fibers were large, 0.4 to 1.4 microns in diameter and 5.0 to 30.0 microns in length. Other researchers report the presence of smaller fibers, generally less than 2 microns in length, in the intestinal lining, blood and several organs after feeding animals asbestos or injecting it into their stomachs. Brown suggests that in his experiments the small fibers may not have entered the lining cells or, alternatively, may have entered more rapidly than larger fibers. "We need to stop the experiments at shorter times," Brown says.

"The observations reported herein provide confirmatory evidence that asbestos fibers can cross the epithelial lining of the intestine," Storeygard and Brown conclude in the December MAYO CLINIC PROCEEDINGS. Brown intends to continue exploring how fibers penetrate different cells and, using electron microscopy, to map the path of asbestos fibers through the body. □

U.S.-Soviet MHD plant generates first power

Just outside Moscow on Dec. 16, U-25B, the newest project in the joint U.S.-Soviet MHD program, began producing electricity and sending it into the Moscow power grid. MHD, which stands for magnetohydrodynamics, is an "advanced" technology that converts heat directly into electricity.

In an MHD generator, an electric field is set up by moving ionized gas, or plasma, through a magnetic field. In U-25B the plasma is produced by burning natural gas. As the plasma is blown past a magnetic field, perpendicular to the plasma flow, ions are deflected to electrodes, setting up the current. Although simple in concept, several of the world's technological superpowers have worked on the design of a reliable working generator for much of the past 20 years with only varying signs of success. Operation of U-25B raises hopes that MHD will soon prove commercially feasible.

In a binary, open-cycle MHD steam generator, such as U-25B, fuel is burned along with a seed material, such as potassium; seed increases plasma conductivity. A heater preheats incoming, compressed outside air as it heads for the burner. Hot gases exiting from the MHD generator pass through a conventional steam generator, the second phase of the binary system. This "bottoming cycle" uses waste energy from the gas, which is no longer hot enough for MHD, to drive steam turbines that power the compressor and an electric generator. Exhaust gases from this stage flow through a seed-recovery system.

Advantages of MHD include simplicity — it has no moving parts — and sulfur removal from fuel. The seed combines with the sulfur and both are removed during seed recovery. Another major advantage is high plant efficiency—perhaps 50 or 60 percent when compared with conventional power-plant efficiencies, on the order of 25 percent for conventional nuclear plants and 35 percent for conventional coal-fired systems. It's the high operating temperatures required of MHD plasmas that permit the theoretically higher energy extraction, hence efficiency, predicted of MHD power systems.

But the high temperatures also present disadvantages — including nitrous-oxide formation and a caustic operating environment for such crucial system components as gas channels, electrodes and air heaters. Slag buildup from coal ash plagues coal-fired models. Although slag acts as a protective coating for walls, replenishing seed lost as it combines with slag is both expensive and inefficient. Scaling components up to commercial size presents other problems.

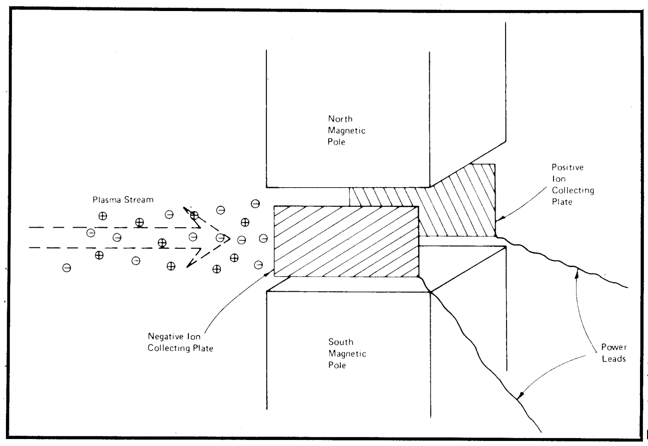
There are other MHD cycles, including those which use conducting liquids in place of the plasma. Their development is not as advanced as open-cycle systems, however.

In theory, MHD can be used as a primary source of power or as a "topping cycle" when combined with conventional combustion or fission power plants. Topping cycles harness heat that is too hot for conventional generating systems.

MHD development has not come easy. Once a world leader in MHD research, the United States mothballed its research program in the early 1960s only to resurrect it a few years later when the vision of unlimited, cheap energy was finally recognized for the myth it is. Now the Soviets lead the United States in most MHD-related technologies, but the progress by both countries is being sped by this cooperative research venture which eliminates costly duplicate research.

George Ruddins of the Department of Energy's MHD program says this joint U.S.-Soviet program is quite a bargain for the U.S. taxpayers. The cost of the superconducting magnet, the only American hardware in U-25B, was about $4 million, compared with the $15 million to $20 million Soviet investment.

How far away is commercial MHD power generation? Perhaps only five or six years, Ruddins says. The Russians are expecting completion of a 500-megawatt (electric) MHD binary-cycle power plant by 1983 or 1984. □



Timothy J. Healy

In MHD, ions in a plasma are blown past a magnetic field and deflected to electrodes. This creates an electric current.