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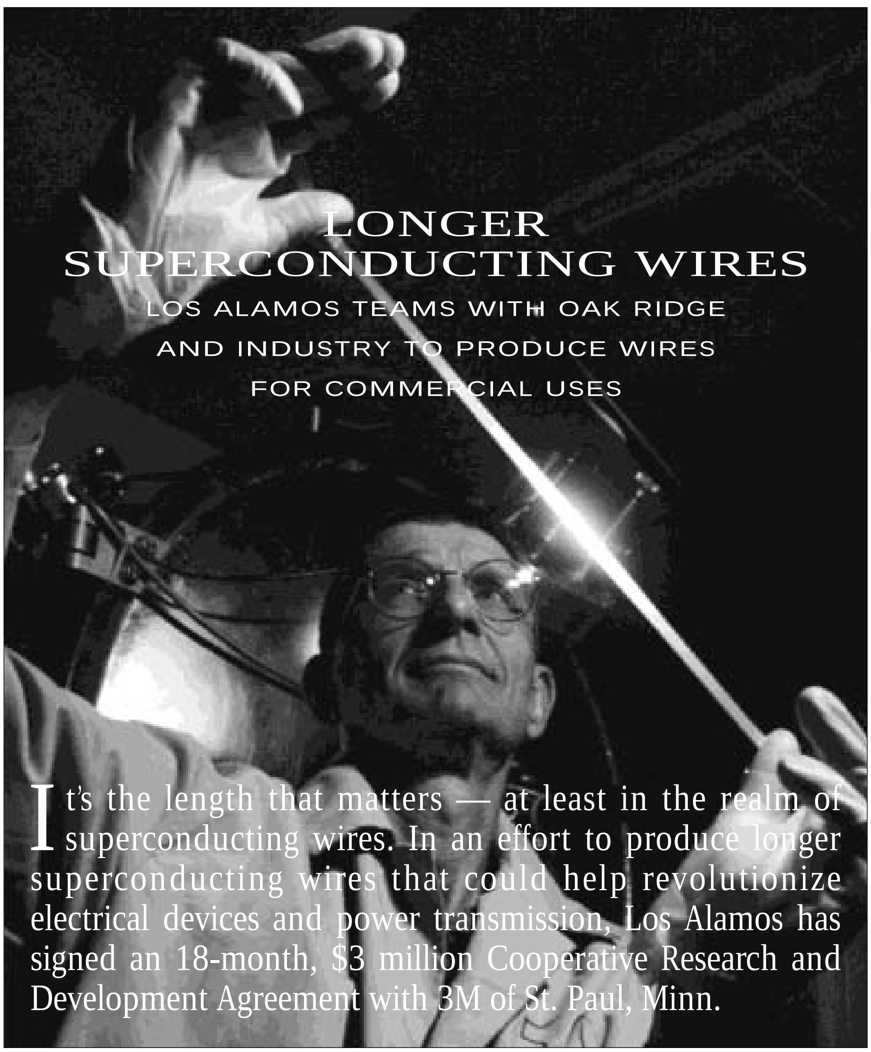
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE
LOS ALAMOS



# LONGER SUPERCONDUCTING WIRES

## LOS ALAMOS TEAMS WITH OAK RIDGE AND INDUSTRY TO PRODUCE WIRES FOR COMMERCIAL USES

It's the length that matters — at least in the realm of superconducting wires. In an effort to produce longer superconducting wires that could help revolutionize electrical devices and power transmission, Los Alamos has signed an 18-month, $3 million Cooperative Research and Development Agreement with 3M of St. Paul, Minn.

As part of the agreement, Los Alamos will join 3M, Southwire Company, Stanford University, and Oak Ridge National Laboratory to develop high-temperature, thin-film superconducting wires that could be used in prototype superconducting motors, generators, power cables, and other electric devices that might be introduced shortly after the turn of the century.

Superconductors are materials, usually ceramics, that lose all electrical resistance when chilled to very low temperatures. High-temperature superconductors are materials that lose resistance at or near the temperature of liquid nitrogen — minus 320 degrees Fahrenheit. Superconducting materials are considered by many to be the "holy grail" of electrical components because they could greatly reduce costs and greatly improve efficiency of power transmission.

Los Alamos' Superconductivity Technology Center has been on the cutting edge of superconductor development — most recently with the introduction of a high-temperature, high-current-density flexible superconducting tape that has a current density nearly 100 times greater than anything previously developed. Current density is a measure of the amount of current that can travel through a cross section of a material. Number 12 copper wire, the wire used in many households, carries less than 800 amperes per square centimeter.

DATELINE LOS ALAMOS

A MONTHLY PUBLICATION OF THE PUBLIC AFFAIRS OFFICE OF LOS ALAMOS NATIONAL LABORATORY

LOS ALAMOS NATIONAL LABORATORY, AN AFFIRMATIVE ACTION / EQUAL OPPORTUNITY EMPLOYER, IS OPERATED BY THE UNIVERSITY OF CALIFORNIA FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. W-7405-ENG-36

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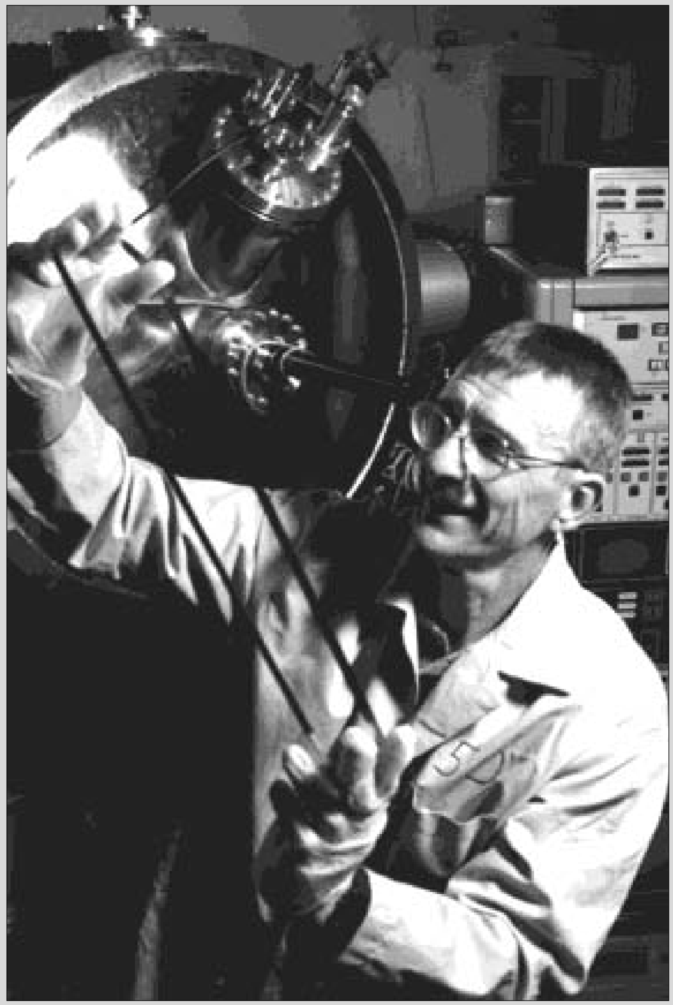

Los Alamos researcher Paul Arendt holds a length of the "Super Tape" that may help revolutionize electrical devices and power transmission. Behind him is an Ion-Beam-Assisted-Deposition apparatus. The unit is used to continuously deposit highly aligned films of metal oxides on long lengths of nickel tape. High-Temperature superconducting thick films are subsequently deposited on top of these metal oxide-nickel tapes using other techniques. Arendt is also pictured on the cover.

So far, Los Alamos researchers have been able to produce one-meter lengths of the "Super Tape" made of a thin film of the superconducting yttrium, barium, and copper oxide deposited on a strip of nickel and cubic zirconia. One-meter lengths are too short for most industrial applications.

The agreement with 3M will explore ways to produce long lengths of the tape at low costs without losing the superconducting properties associated with the tape.

In addition, the CRADA will explore ways to capitalize on an Oak Ridge superconducting development known as Rolling-Assisted Biaxially Textured Substrates: a technique in which superconducting films are deposited on metals to produce high-temperature superconducting tapes. Oak Ridge's RABITS also have shown current densities of one million amperes per square centimeter.

"If there is a way to scale up production of the Los Alamos and Oak Ridge technologies for commercial use, their potential in applications like motors, generators, transformers, current limiters, underground power cables and magnetic energy storage is incredible," said William Coyne, senior vice president of 3M research and development. "Products using electrical wiring could be vastly improved. For instance, transformers could be produced at half the weight and operate without oil, and far more efficient motors would run more quietly and produce double the output."

The nation's demand for electricity is expected to nearly double by 2030 so the use and development of superconducting materials in the next 20 years may play a key role in helping the nation and the world meet increasing power requirements.

The Los Alamos Superconductivity Technology Center is one of three national sites funded by the Department of Energy to develop the technology base necessary for U.S. industry to proceed with commercial development of electric power and electric device applications of high-temperature superconductivity.

A diversified manufacturing company, 3M produces more than 50,000 products for the industrial, commercial, consumer, and health-care industries. Southwire, a privately owned company near Atlanta, is one of the world's major producers of copper wire and has an interest in producing superconducting wire. Oak Ridge National Laboratory is managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy.

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# INTERNATIONAL COLLABORATION

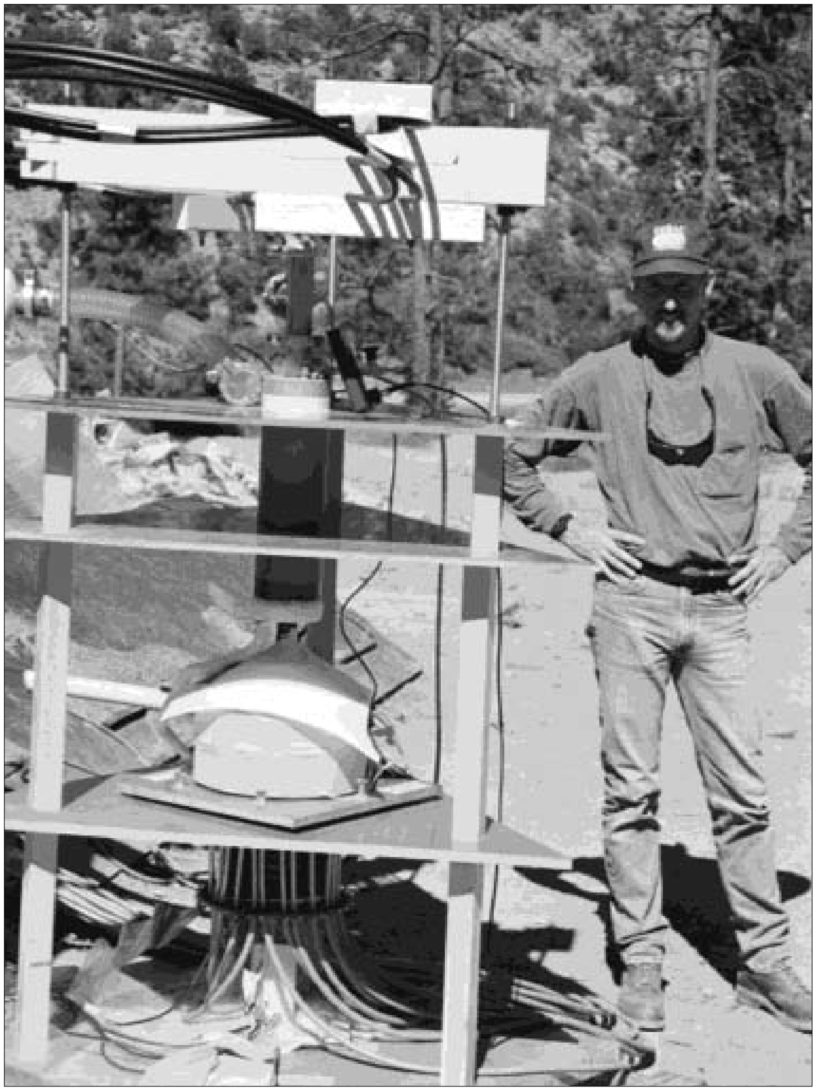
## SCIENTISTS PROBE HOW MATERIALS CONDUCT ELECTRICITY IN EXTREME CONDITIONS

In a remote corner of Los Alamos National Laboratory, scientists from around the world spent weeks setting up an apparatus designed to measure what happens to certain compounds under extremely high magnetic fields. Then they blew it to bits.

The "Dirac" experimental campaign is an international collaboration begun in 1996 co-sponsored by several Los Alamos programs including Laboratory Directed Research and Development (LDRD), High-Energy Density Physics, and the National High Magnetic Field Laboratory (NHMFL) to investigate the atomic structure and chemistry of materials by subjecting them to an exceedingly strong pulsed magnetic field driven by an explosive charge.

The scientists are probing how materials conduct electricity and transmit light in extreme conditions. The magnetic forces created briefly in the

An electromagnet surrounded by 35 pounds of explosives, produced this perfectly uniform implosion. The magnetic forces created by the explosion gives scientists insights on advanced materials.



Los Alamos co-principal investigator Jeff Goettee stands next to the Russian-designed and -built MC1 generator.

experiment by the explosion make it possible to investigate aspects of the structure of condensed matter that are otherwise impossible to study.

Insights from these experiments may help in the design of superconductors and better semiconductors. But for the scientists, the payoff is the glimpse at secrets that are hidden under normal conditions but revealed under extremely high magnetic fields.

“We are measuring phenomena never seen before,” said Laurence Campbell, Los Alamos project leader of NHMFL.

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Scientists from Australia, Belgium, Germany, Japan, and Russia joined Los Alamos researchers to conduct four "shots" in June.

"All the world's experts on compressed flux field generators were assembled here," said Campbell. "And Los Alamos is the only place these experiments could occur today."

Los Alamos has the special facilities required for such a test, including a bunker packed with electronics where the scientists control and record the shot. The Laboratory has unmatched expertise with conventional explosives and is home to a branch of the National High Magnetic Field Laboratory, a U.S. consortium dedicated to magnetic field research.

"This is an opportunity to conduct these experiments in a technical environment we cannot achieve at home, particularly the very low temperatures for the samples," said Alexander Bykov of Arzamas 16, now called Sarov, the Russian equivalent of Los Alamos National Laboratory.

To attain the intense magnetic fields required, the research team placed sample materials inside an electromagnet crafted by the Russians. The samples were cooled to less than two degrees above absolute zero. The magnet was surrounded with about 35 pounds of explosives, arranged to produce a perfectly uniform implosion.

In the millionths of a second before the equipment turned to dust, sensors captured measurements of how the samples' electrical resistance and light transmission changed as the magnetic field was squeezed and concentrated by the blast.

Magnetic field strength is measured in tesla. One tesla is about 20,000 times stronger than Earth's field. Sustained fields in research magnets have exceeded 60 tesla. The Dirac experiments have achieved momentary pulsed fields reaching 850 tesla.

"We've gotten excellent results," said Campbell. "We've achieved higher fields at lower temperatures than ever seen before."

The NHMFL mission set forth by the National Science Foundation is to provide the highest magnetic fields and necessary services for scientific research conducted by users from a wide range of disciplines, including physics, chemistry, materials science, engineering, biology, and geology.

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# "DON'T STEP ON A CRACK"

## SIMPLE TEST DEVELOPED FOR EARLY DETECTION OF FAILING CONCRETE

Researchers at Los Alamos have developed a simple, environmentally friendly test to detect concrete flaws even before cracks and other signs of failure become visible. The test identifies one of the most common causes of concrete degradation, a reaction between alkali and silica, that causes the building material — of which an estimated 260 million cubic yards were used in the United States last year — to fail prematurely.

Researchers Bill Carey (left) and George Guthrie pour chemicals onto a concrete core sample to test for the presence of a degrading gel, which can cause concrete to deteriorate over time.

Concrete is a mixture of cement and aggregate, typically rock and sand. The alkali-silica reaction can occur when cement is mixed with aggregate rich in certain types of silica materials. The silica reacts with alkalis in cement and forms a gel inside the concrete. The gel expands dramatically in the presence of moisture, creating a network of microscopic cracks. Freezing and thawing worsen the cracks over time until, eventually, the concrete becomes structurally unsound.

Many areas in the United States, including New Mexico with its abundance of volcanic rock, have aggregates that promote alkali-silica reaction in concrete. Because so many highways and highway bridges are constructed with concrete, the alkali-silica reaction is of great concern to transportation officials.

The researchers are helping New Mexico State Highway and Transportation officials identify structures that may fall prey to alkali-silica reaction long before cracks are apparent. They are also working with the New Mexico Alliance for Transportation Research to develop a broader effort for improving the durability of concrete.

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A core sample at the start of testing.

The test developed at Los Alamos not only shows when an alkali-silica reaction is occurring, it has revealed information about how it occurs. The test involves a set of chemicals that can be poured on concrete core samples in the field. If the degrading gel is there, the chemicals stick to it and color it. Test results are ready in minutes.

The Federal Highway Administration currently recommends a test that uses uranyl acetate, a radioactive uranium compound. The compound must be viewed under a black light in total darkness as areas where gel may have formed fluoresce under the light.

The researchers believe their test has some important advantages over the uranyl acetate test. In addition to being nonhazardous, the Los Alamos test doesn't require any special viewing apparatus and is much cheaper to use and dispose of afterward. The Los Alamos test also is chemically specific and much less likely to lead to false positives, a problem with the uranyl acetate test.

As a consequence of their work, the researchers have identified two distinct types of gels that form from the alkali-silica reaction and have developed a set of chemicals to indicate the presence of the second gel type. The pair also are developing a staining test to detect other deleterious reaction products.

The new test has the potential to save millions of dollars each year. With early detection of alkali-silica reaction, contractors can identify whether concrete is going to undergo quick degradation. If so, they can use a different source of cement or aggregate. In addition, the test may allow concrete-industry personnel to identify whether an aggregate quarry is going to produce, or is producing, material that leads to alkali-silica reaction.

More importantly, the researchers believe that ultimately, as a result of their research, they can determine exactly why the gels are forming and prevent them from happening in the first place.

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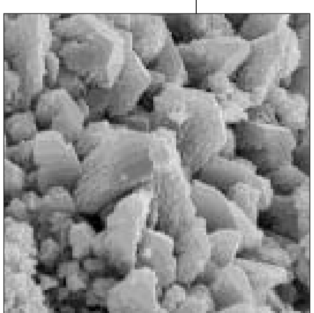
# PAVING THE WAY FOR BETTER CEMENT

## SUPERCRITICAL $CO_2$ STRENGTHENS CEMENT AND GIVES NEW LIFE TO WASTE MATERIALS



↑ Electron microscopy pictures (magnified 8500X) of untreated (top) and treated cement.

Los Alamos researchers are developing an environmentally friendly process to harden cement and create a new class of strong and lightweight building and fabrication materials.

The process strengthens common portland- or lime-cemented materials and clays by treating them with carbon dioxide under high pressure. The process also converts waste materials — including fly ash from coal-burning power plants, alum sludge from water-treatment plants, and blast furnace slag — into strong and inexpensive building products. Cement treated with $CO_2$ also may improve the safe storage of radioactive waste.

The process, patented by Roger Jones Jr. of Materials Technology Limited of Reno, Nev., may lead to new building materials, consumer goods, auto parts, and other products. According to Jones, the process creates recyclable materials that will be competitive with certain metals, plastics, and wood products.

Los Alamos' continuing role in developing the improved cement is to optimize treatment conditions and help design a treatment facility. The Los Alamos researchers also see in the improved cement a new area of materials science to pursue.

Under conditions of high temperature and pressure, carbon dioxide becomes first a liquid, then enters a phase called "supercritical" and exhibits both gas and liquid properties. Supercritical carbon dioxide can expand like a gas to fill its container or diffuse into the tiniest pores of its boundary material; or, on the other hand, because supercritical carbon dioxide has a high density like a liquid, it can dissolve substances and carry them away. In this application, supercritical carbon dioxide pulls water molecules out of the cement.

Chemically, the process converts the hydroxide of cement to a carbonate, with water as the byproduct. This chemical reaction occurs naturally, but may take thousand of years. For example, the Great Wall of China has not yet reached a chemically neutral state, whereas the supercritical carbon dioxide treatment produces a chemically stable material in minutes or hours. In fact, it is not really cement anymore, it is pourable limestone.

The researchers demonstrate the effect of supercritical carbon dioxide with two chunks of bonded fly ash, a waste product from coal-burning power plants. Set in a pan of water, the untreated sample quickly crumbles and dissolves, obviously useless as a building material. But the treated sample remains impervious to the water. Treated fly ash could make a strong, lightweight, and economically attractive material for wall board, flooring, and other construction products.

Large-scale use of supercritical carbon dioxide is not new to industry. Commercial operations have applied the same technology for years to make vegetable oils and decaffeinate coffee, so the researchers don't foresee difficulties treating large volumes of cement blocks or massive columns and slabs. Even the U.S. Air Force has expressed interest in the technology for building high-strength concrete slabs for runways.

Applying supercritical carbon dioxide through a high-pressure nozzle could harden large surfaces of existing concrete structures and seal them against penetrating chemicals. The treated surfaces would resist chipping or scaling because the transition from the thin, very hard exterior to untreated interior concrete would be gradual.

Researcher Jerry Barton operates the high-pressure $CO_2$ apparatus in the Super Scrub Facility at Los Alamos. ↓

Large amounts of carbon dioxide produced by coal- and oil-burning power plants and gasoline engines are blamed in part for a trend toward global warming. But the cement treatment process, by permanently removing carbon dioxide from the atmosphere and locking it into building products, actually helps reduce the impact of coal and petrochemical use. Research is under way to use both the fly ash and carbon dioxide expelled by coal-burning plants to produce construction materials.

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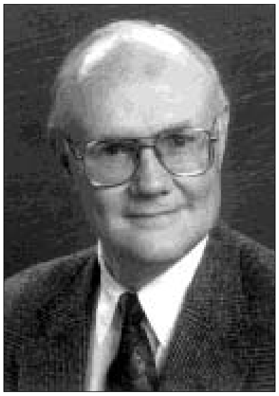
## BRIEFLY ...



DON BRYSON, DEPUTY DIVISION DIRECTOR OF LOS ALAMOS BUSINESS OPERATIONS, RECENTLY RECEIVED VICE PRESIDENT AL GORE'S HAMMER AWARD for his efforts as a member of the Federal/Contractor Purchasing Council to reduce procurement costs and improve business practices across the entire Department of Energy complex. The council represents all major DOE contractors and the federal contracting community. In its two years of existence, the council is credited with streamlining purchasing and other business activities, saving DOE about $20 million. Bryson received a $6 hammer (similar to an ordinary hammer for which the U.S. government once paid $400), a ribbon, and a congratulatory note from Gore. Bryson represented Los Alamos, Lawrence Livermore, and E. O. Lawrence Berkeley national laboratories on the council.



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DATELINE LOS ALAMOS

A Monthly Publication of the Public Affairs Office of Los Alamos National Laboratory

Nonprofit Organization
U.S. Postage Paid
Albuquerque, NM
Permit No. 532

LALP-97-1-8

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