The papers document a wide-ranging effort to study biological and chemical weapons—including bacteria, nerve agents, and at least one agricultural pest. The tests were conducted from Florida to Alaska, on islands under U.S. jurisdiction and in Canada and the United Kingdom. Several of the tests involved simulants, agents resembling the real thing but considered harmless, such as *Bacillus globigii*, a bug now classified as a strain of *Bacillus subtilis* that is a close relative of the anthrax bacterium.

But real pathogens and toxic chemicals were used in more than 20 of the tests revealed so far. In an operation dubbed Shady Grove, for instance, the U.S.S. *Granville S. Hall* and five army tugboats in the Pacific were sprayed with two species of bacteria: *Francisella tularensis*, which causes tularemia, and *Coxiella burnetii*, the cause of Q fever. Both microbes can cause severe and potentially fatal infections.

U.S. Navy and Army crew members involved in this test "should have been fully informed of the details," according to the fact sheet, and "should have worn appropriate … protective equipment." But during a Senate committee hearing last week, retired Navy commander Jack Alderson, who participated in Shady Grove, testified that he was never told about the test's purpose and that no protective materials were issued. Officials say test records contain no evidence that anyone got sick, although it's not clear whether the microbes caused no infections or whether those infected were successfully treated with antibiotics.

More than a dozen tests used nerve agents, including sarin and the extremely lethal VX. In these tests—designed to show, among other things, how well the agents dispersed under various climate conditions and whether they clung to ships, clothing, or the ground—far fewer participants were involved, and they wore protective gear, according to the Pentagon.

Other trials illustrate the nation's broad interest in biowarfare. In operation "Magic Sword," *Aedes aegypti* mosquitoes, which can transmit yellow and dengue fevers, were released off the coast of Baker Island, a U.S. atoll in the North Pacific, to work out the logistics of mosquito-borne viral attacks. (The mosquitoes weren't infected, and they were eradicated after the exercise.) And in an experiment in Florida, the Army used a plane to spray a fungus that causes a devastating disease called stem rust. The goal was to see whether it reduced crop yields in test plots.

The Pentagon is trying to track down and inform more than 5000 people involved in the tests. So far, more than 50 veterans have filed claims with the Department of Veterans Affairs (VA) because they believe they're suffering from conditions triggered by the tests. But unless the vets share some common set of symptoms—which VA says is not the case—it will be next to impossible to link specific complaints to the tests, says Harvard biologist and arms control expert Matthew Meselson. The Institute of Medicine has just begun working on a $3 million study funded by VA that will compare health status and mortality among test participants to that of a control group of veterans.

Meanwhile, biological and chemical arms experts are scouring the documents for details about the U.S. program, which President Nixon ended in 1970. But most say there's little new information. An unclassified Army document published in 1977 confirmed that field tests with biological agents had taken place, says Meselson, who's surprised that the fact sheets have triggered so much publicity. "I guess the media tends to forget these things," he says. Still, the stream of documents illustrates the surprisingly large scale of the research program, says Jonathan Tucker of the Monterey Institute's Center for Nonproliferation Studies in Washington, D.C.

The revelations also serve another, unintended purpose, says Leonard Cole of Rutgers University in Newark, New Jersey, author of a book about previously revealed Army experiments on unwitting subjects. They serve as a reminder to authorities not to conduct experiments—even those in the national interest—without first obtaining informed consent from the participants.

–MARTIN ENSERINK

POWER TOOLS

Into Painless Piercing? Try It With Microwaves

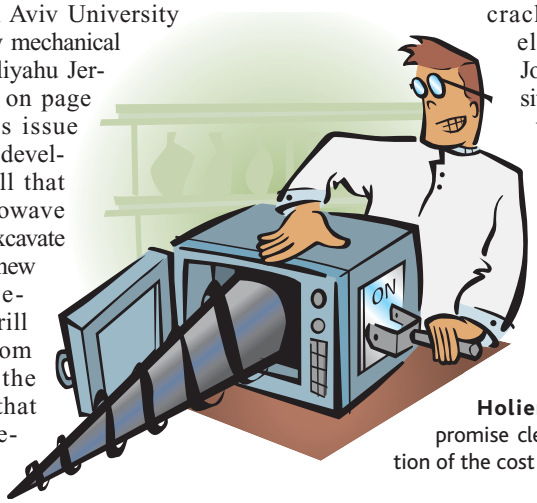
Anyone unfortunate enough to remain awake in the dentist's chair may be acutely aware of at least two of the three primary drawbacks to using a spinning mechanical drill to grind a hole: noise, vibration, and flying debris. The drill bit feels the pain, too, eventually wearing out or breaking under the repeated stress. Now, a Tel Aviv University team led by mechanical engineer Eliyahu Jerby reports on page 587 of this issue that it has developed a drill that uses microwave energy to excavate solids. The new microwave-powered drill suffers from none of the problems that plague mechanical drills. It is silent, steady, and dust-free, and the bits almost never wear out.

Drilling with electromagnetic radiation is nothing new. For years, engineers and scientists have been using the tightly focused light beams from laser drills to punch tiny holes as small as 1 micrometer in everything from semiconductor circuit boards to human bone. But laser drills are expensive, and a several-hundred-thousand-dollar laser drill might not always be the right tool to quietly put a 1-millimeter-wide hole in a concrete block.

So Jerby's team cooked up a low-cost alternative in the kitchen. "We pulled the magnetron from a domestic microwave oven," Jerby says. "It cost about $20." To focus the microwaves, radiation from the magnetron is directed into a rectangular metal box that guides the microwaves into one end of a piece of coaxial cable—"just like the cable going to your TV, except ours is a little stiffer," Jerby explains. The other end of the cable is placed near the surface where the hole will be drilled.

By adjusting a mirror at one end of the metal box, the researchers can match the impedance of the coaxial cable to the surface being drilled. That tuning allows microwave energy to travel into the surface instead of being reflected, thus concentrating the energy of the microwaves into a spot just below the surface. As the spot starts to heat up, changes in the material cause a peculiar thing to happen: Instead of cooling more rapidly to shed the excess heat, the spot starts to soak up even more energy than before. A molten hot spot forms beneath the surface of the material, and a drill bit passing down the center of the coaxial cable can easily scoop out the molten material.

Jerby's team has already used a prototype microwave drill to put holes with diameters ranging from about 1 millimeter to 1 centimeter in ceramics, concrete, basalt, glass, and silicon. Because regions near the hot spot stay relatively cool, even brittle materials don't build up enough thermal stress to shatter, Jerby says. "The cool thing is that you can drill without wear, breakage, or cracking the tool bit," says electromagnetic scientist John Booske of the University of Wisconsin, Madison, who believes that the microwave drill will be particularly useful for drilling ceramics such as those used to mount semiconductor devices on a circuit board. "It would also be great for drilling jewelry and pot-



Holier than thou. Microwaves promise clean, silent drilling at a fraction of the cost of lasers.

ILLUSTRATION: TIM SMITH

tery," says Booske. Jerby adds another low-tech application of his silent drill: concrete construction. "If you have ever had a neighbor drill into a concrete wall next to your apartment at midnight, you know what I mean," he says.

But don't expect to see the microwave drill during your next dental checkup. Although the lab model emits less radiation than a typical home microwave oven, Jerby says, "safety is still a big concern." To keep stray microwaves from cooking the internal organs of an unwary drill operator, production models of the microwave drill either will be completely enclosed, like an oven, or will use a shielding plate. **–MARK SINCELL**

Mark Sincell writes from Houston, Texas.

FISHERIES SCIENCE

Miscue Raises Doubts About Survey Data

A misrigged trawling net has brought a haul of problems for the U.S. National Marine Fisheries Service (NMFS). The faulty net has been used for the past 2 years in NMFS surveys of Atlantic fish populations, which help regulators set catch limits for cod and other important species. Now, some commercial fishers and members of Congress want the government to delay controversial catch restrictions that they say might be based on flawed data.

All wet? Critics say mismarked trawl net (*above*) might have biased fish population counts.

The controversy, which some have dubbed Trawlgate, was triggered last month when NMFS officials disclosed that the 1000-meter-long cables aboard the government research vessel *Albatross IV* were mismarked. The cables are supposed to carry marks every 50 meters, so that researchers can repeatedly pull trawl nets evenly across the bottom in annual efforts to track population trends. But officials said that the uneven spacing caused one cable to be as much as 2 meters longer than the other during typical tows, in which the net is lowered 70 to 250 meters. That could make the trawl lopsided and possibly reduce catches. The admission, prompted by a tip from a commercial fisher who 2 years ago noticed contractors misapplying the marks, produced a hailstorm of criticism from fishing groups. NMFS quickly invited six critics on a 3-day cruise that examined the troubled net with underwater video cameras and called a 2-day summit between scientists and fishers. On 3 October, the two sides reported that the error had an as-yet-undetermined "effect" on at least eight surveys over the last 2 years.

Independent researchers say the scientific impact of the misrigging is likely to be minor. But the mishap has accelerated efforts to overhaul the 60-year-old Atlantic survey program, which senior NMFS researchers at the summit described as "broken." Government officials and commercial fishers are already discussing ways to gather more and better data by using upgraded government equipment and getting more help from commercial trawlers.

Until such improvements are in place, some critics say the government should drop plans to help some stocks recover from decades of overfishing by limiting catches in New England and elsewhere. A federal court, for instance, has ordered New England regulators to cut catches by one-third or more by next August (*Science*, 17 May, p. 1229), a deadline Representative Bill Delahunt (D–MA) now wants the judge to delay for up to 2 years. "Given the documented shortcomings of the research, the only sensible course is to pause for a deep breath," he says. NMFS officials, however, note that almost none of the potentially flawed data were used in formulating the recovery plan, and they say it should move ahead.

Government fisheries researchers, meanwhile, hope that the painful glitch will bolster their push for better—and better funded—stock-assessment efforts. "We've been wanting to make improvements for a while," says fisheries scientist Russell Brown of the Northeast Fisheries Science Center in Woods Hole, Massachusetts. "We just didn't expect to have to do it in this kind of charged atmosphere." **–DAVID MALAKOFF**

CREDITS: NMFS

ScienceScope

Linear Leaders The global competition to build the next huge linear electron-positron collider, a 30-kilometer-long machine aimed at answering fundamental questions in physics, appears to have become a two-horse race. Four teams are working on designs for the multibillion-dollar device, which would pick up the baton from the Large Hadron Collider now under construction at CERN near Geneva. But last week, at a meeting of the International Committee for Future Accelerators, Germany's TESLA collider and a joint bid from the Stanford Linear Accelerator Center (SLAC) in California and Japan's KEK particle physics lab emerged as the clear front-runners.

A panel that has spent 15 months vetting the four entries has identified about 30 R&D issues that must be addressed before physicists try to sell their favored design to funders. But panel chair Greg Loew of SLAC told *Science* that there are no apparent technical "showstoppers" for the top two entries.

Advancing Aurora The European Space Agency (ESA) is getting ready to give potential funders their first look at blueprints for Aurora, a planetary research program that aims to send human explorers to the moon and Mars by 2030. As a first step, Aurora planners earlier this month commissioned studies of four robotic missions that would test the technologies needed to send a rover to Mars and return samples to Earth by 2009. In December, Aurora officials will present study results to ESA's 15 member nations and Canada. Funding decisions could come as early as next summer.

Fire Fallout In an ironic twist, the cost of fighting this year's record fires in the western United States has left many fire scientists without funding for studies aimed at preventing future burns. To pay for extinguishing fires on more than 2.5 million hectares, the U.S. Forest Service (USFS) has diverted at least $27 million designated for research. USFS officials say most of the money should be restored by spending bills pending in Congress. But for the moment, fire researchers have to cool their heels and possibly delay some planned projects.

Contributors: Jocelyn Kaiser, John Bohannon, Robert F. Service, Daniel Clery, Alexander Hellemans, Ben Shouse