

Award-Winning Research Shows How Hydrogen Neutralizes an Elusive Microelectronic Defect

For a decade or more, people working with microelectronics have known of the existence of a certain type of microscopic defect.

They knew that it could make transistors in microelectronic circuits operate unreliably, or not at all. They gave the defect a name: the "P_b center." (The name refers to the fact that the defect is one of three "paramagnetic centers" labeled a, b, and c.) They even knew that heating microcircuits in hydrogen gas could alleviate the problems it caused.

But they weren't sure what the P_b center really was, or why hydrogen helped.

New Picture

Over the course of several years, research by Sandians in Microstructure and Defects Physics Div. 1112 changed that picture. Their work, combining experiment and theory, has earned an award for "sustained outstanding research in metallurgy and ceramics" from DOE's Office of Basic Energy Sciences (BES), Division of Materials Sciences.

Named as winners of the award in the 1990 Materials Sciences Research Competition are Keith Brower (recently transferred from 1112 to 9221), Pete Richards, Herman Stein (both 1112), and Div. 1112 Supervisor Sam Myers. Their research was funded by BES. Along with DOE recognition of the four Sandians, the award also

provides funds for equipment purchases.

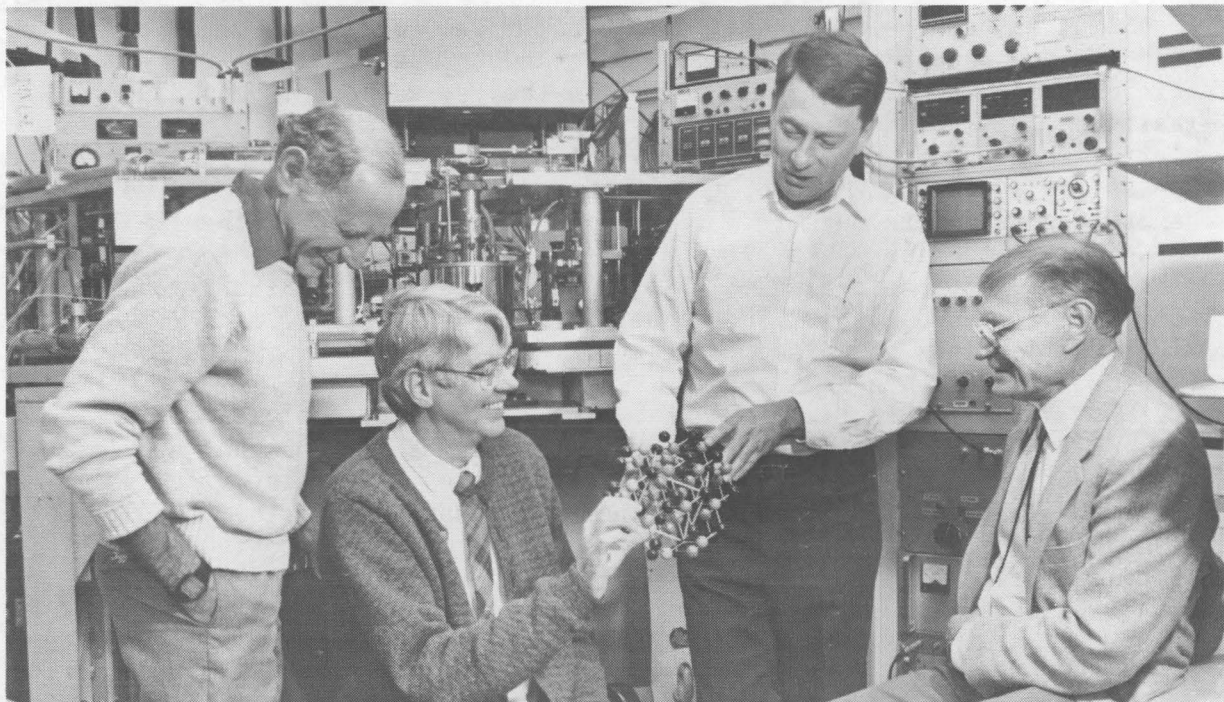
"What we did that is especially useful," explains Sam, "is establish a predictive understanding of the interaction between hydrogen and defects in the structure of an important microelectronic material. We did this through a real mix of work. Some of it has been going on for a decade, and some of it was done just in the last couple of years. It's mutually complementary research by several people, in support of a common theme."

Research on several fronts was necessary be-

cause of the complexity of the system being studied: silicon dioxide and its interface with silicon, the defects in the oxide and at the interface, and the interactions of hydrogen with the defects.

This area is important because many microelectronic circuit components contain a conducting layer on a layer of silicon dioxide on a silicon substrate — MOS for short, standing for metal-oxide-semiconductor (the conducting layer is often metal). Annealing (heating) the MOS material

(Continued on Page Four)



AWARD WINNERS for "sustained outstanding research in metallurgy and ceramics" discuss a molecular model: (from left) Pete Richards (1211), Keith Brower (9221), Sam Myers, and Herman Stein (both 1211).

'Particularly Satisfying' Recognition

This Basic Energy Sciences award is particularly satisfying from several viewpoints. First, it continues Sandia's record of recognition by our scientific peers who judge the nominations. In the last six years, Sandia has won 11 awards, more than any other DOE laboratory. Second, the award recognizes senior Sandia researchers who have become internationally recognized in the field of defect physics. Finally, the work has applicability to the processing of microelectronic devices and their radiation resistance, something of great concern to Sandia.

Fred Vook (1100)

An Opportunity to Help Families

Desert Storm Family Fund Established

Sandians will soon have an opportunity to help New Mexico family members of military service men and women participating in Operation Desert Storm.

The "Desert Storm Family Fund" is a special project of United Way of Greater Albuquerque. Information will be distributed next week to Albuquerque-based Sandians, and employees who wish to participate will be asked to mail their contributions directly to a special fund, says Joe Laval of Community Relations Div. 3163.

Joe says the idea for the project came from a group of concerned Sandians who began meeting late last year to determine how Labs employees could assist military dependents suffering financial hardships from Desert Storm (then Desert Shield).

"Although the fund is being coordinated by the Albuquerque United Way office, we want to emphasize that the money raised will be distributed to help military dependents throughout New Mexico," says Dick Burcham (5128), spokesman for the Sandia employee group. "Many of the needy military families are in rural areas that don't have a large population base to help provide support, and we want to ensure that our helping hand extends to these areas."

(Continued on Page Two)

Labs Accomplishments for FY90: See Middle Section

LAB NEWS

VOL. 43, NO. 3 SANDIA NATIONAL LABORATORIES FEBRUARY 8, 1991

New Series Begins Today

'Management Town Meetings' Offer Informal Exchange of Views

"Management Town Meetings," an addition to the Labs' ongoing campaign to improve communication within Sandia's workforce, will begin today, Friday, Feb. 8.

Gerry Yonas, Director of Laboratory Development 400, starts the monthly series with a talk titled "Forces for Change," beginning at 11 a.m. at the Technology Transfer Center (Bldg. 825).

"This session will draw upon information that was discussed at the Large Staff conference last fall and the refinements that continued as Al Narath and many Sandians prepared input for the Secretary of Energy's Advisory Board [SEAB]," says Gerry. "Because SEAB is currently studying the future of the DOE labs, this is a subject of great importance to all of us."

As the program develops, the Town Meetings are expected to explore many diverse subjects, for example, last-minute Tiger Team preparations, change management, technology transfer, the weapons program,

environmental technology, the state of the *Strategic Plan*, the Sandia budget, reimbursable programs, and new technical initiatives such as robotics and space.

The purpose of Management Town Meetings is to acquaint Sandians with "behind-the-scenes" activities that are shaping the future of the Labs. Their tone was set by President Al Narath when he conducted a series of meetings in response to publicity about the Labs' change-management consulting contract. The goal is to present informal "shirtsleeve sessions" at which audience members will have ample time to ask questions.

Attendees should bring their badges because most of the meetings will be closed to non-Sandians in order to encourage a free and deliberative exchange of views. Videotapes, marked for internal viewing only, will be provided to Sandia, Livermore; Tonopah Test Range; and Kauai Test Facility. Tapes will also be available through the Technical Library.

This & That

It Was a Very Good Year - After reading the Labs Accomplishments in this issue (see middle section), I think the Sinatra song title is an appropriate description. The 115 technical and administrative accomplishments (selected by Sandia's VPs) highlight our FY90 work. Sandia doesn't publish a formal annual report, but this special section is the closest thing.

LAB NEWS writer Linda Doran coordinated the Labs Accomplishments section this year. Thanks to her and to the many folks throughout Sandia who submitted and reviewed the copy.

The annual "State of the Labs" supplement will be published soon. It features in-depth interviews with the President and Executive VPs.

* * *

Mug Madness - That's what ensued after we "advertised" the handsome new Sandia coffee mugs for sale in our Jan. 25 issue. Our initial stock was completely gone before the day was done. John Shunny (retired LAB NEWS editor who stocks them here and distributes profits to charity) brought in more last week - all he had. But they were all spoken for by the time he got them here on Jan. 29. John has ordered several hundred more mugs from the merry mug maker and says they'll be here in four to five weeks. If you want to reserve one (or more) come by the LAB NEWS office in Bldg. 814 (or send a note to Div. 3162) with your name, office phone number, and number of mugs you want (\$7 each). Livermore Sandians can place their mug orders with Barry Schrader (8522) in Bldg. 911, Rm. 134.

* * *

Big Bucks - Many folks, probably including some Sandians, aren't aware that Sandia pays state gross receipts taxes, commonly called sales taxes. Neal McEwen, Supervisor of General Accounting Div. 151, reports that the Labs paid \$39 million in these taxes to New Mexico in FY90. (Sandia gross receipts are based on costs incurred under our contract with DOE, for services we provide in New Mexico.)

* * *

"Favorite Old Photo" Guidelines - As space allows, we like to publish "favorite old photos" and captions provided by Sandians. Most likely to make it are photos that aren't simply old, but those that also include action, show some historical perspective, emphasize the unusual, or illustrate contrast between the times. A picture of your Great Grandpa Bill standing and smiling at us probably won't make it. A good shot of the old boy boxing a kangaroo in the first saloon in New Mexico would have a great chance. Get the picture?

If you have an old photo that you'd like us to consider, bring it by the LAB NEWS office in Bldg. 814, Rm. 1. We can probably tell you on the spot if it's a good candidate. Livermore folks who have candidate photos can submit them to Barry Schrader in Bldg. 911, Rm. 134.

* * *

It's Around Here Somewhere - Did you observe National Clean-Off-Your-Desk Day on Jan. 21? An article in that day's "Business Outlook" section of the *Albuquerque Journal* pointed out that a messy desk is responsible for as many as three hours a week in lost time and is a major cause of stress. By the way, does anyone have a copy of the article? I clipped it, but misplaced it. Probably should check these piles on my desk.

•LP

Lecture to View Economic Effects Of Persian Gulf War



The potential impact of the Persian Gulf war on national and local economic trends will be discussed by Lee Zink at the next Community Focus lecture. The program will be in the Technology Transfer Center on Monday, Feb. 18, beginning at noon.

An associate vice president for research, business, and government relations at the University



LEE ZINK

of New Mexico, Zink is one of the state's leading economists. He is also a faculty member of the UNM economics department. He coordinates the UNM Business Link, a university-wide effort to serve the state's business and professional communities.

His major research has concentrated on the New Mexico economy.

Zink was president of the Greater Albuquerque Chamber of Commerce in 1981 and chairperson of the first New Mexico Governor's Council of Economic Advisors from 1974 to 1978. He was also the state's first Secretary for Economic Development in the Governor's cabinet in 1975.

Currently he is a member of the board of directors of the First National Bank in Albuquerque, chairperson of the Albuquerque Advisory Committee for UNICEF, and a member of the Albuquerque Economic Forum.

The next speaker in the Community Focus series will be Kathy Baca, executive director of the New Mexico Crime Stoppers Commission. She will speak Friday, March 22, at noon in the TTC on "Operation Crackdown: Drugs and Crime in New Mexico."

The series is sponsored by Community Relations Div. 3163.

Congratulations

To Wendy (2523) and Mike (1831) Cieslak, a daughter, Linda Marie, Dec. 7.

To Laurie and Steve (3545) Armistead, a son, Devon Eugene, Dec. 17.

To Tania Hake (6412) and Carl Vanecek (2545), married in Tampa, Fla., Dec. 29.

To Susan and Paul (7522) Romero, a daughter, Christine Marie, Jan. 11.

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Desert Storm Family Fund Established

United Way says the money raised will go to support any necessary increase in already existing programs that serve military families affected by Desert Storm.

A steering committee of representatives from Sandia, United Way, the American Red Cross, and other organizations connected with the special fund drive will set guidelines for allocating the money raised. Other organizations with representatives are the New Mexico National Guard and Reserves; Family Support Units within Kirtland Air Force Base (AFB), Holloman AFB, and Cannon AFB; and the Persian Gulf Support Group.

It is unusual for Sandia to participate in special fund-raising drives, says Herb Pitts, Director of Information and Communication Services 3100 and a long-time United Way supporter. "We get such outstanding participation during our annual United Way [ECP and LEAP] campaigns that we don't often support other fund-raising efforts at the Labs," he explains, "but we think this is a special case.

"The war is working a real financial hard-

ship on some New Mexico military families. For example, many families of reservists called to active duty are having difficulty making housing and utility payments because the reservists' military pay is often much less than what their civilian job paid. Also, the call-up of the reservists happened so quickly in many cases that they simply didn't have time to make alternate financial arrangements.

"The employee group that organized this effort has demonstrated once again that Sandians care," Herb continues. "Now the rest of us can follow up."

•LP

Sympathy

To Paul Romero (7522) on the death of his sister in Houston, Tex., Dec. 15.

To Francisco Sanchez (7818) on the death of his father in Tijeras, Jan. 10.

To Jerry Smith (2564) on the death of his mother in Beaumont, Tex., Jan. 24.

To Dan Naru (3733) on the death of his mother in Mich., Jan. 30.

Former Rock Hound Makes Good**Sandia Scientist Coauthors Mineralogy Books**

A physical chemist at Sandia, Livermore, who has maintained an outside interest in minerals since he was a child, coauthored two books during the past year, one of which will be part of a five-volume set.

Monte Nichols (8311) recalls that when he was 9, his parents bought him a small box of 100 minerals during a move from Iowa to Arizona. The minerals kept him occupied during the long, hot ride.

"I was fascinated by all those minerals and just couldn't get enough of them," says Monte.

His initial exposure to minerals led to frequent rock hunting trips in Arizona until he went away to college. "When I was 15, my father used to drive me and a friend out to abandoned mine sites so we could look for certain minerals. We used carbide lights and would go a couple hundred feet down the mine shaft while Dad waited for us by the car, sometimes for several hours."

One of the most harrowing experiences he ever had in those days was when a companion fell and hit his head on a stalagmite. The three other explorers on the trip helped carry the youth out through narrow passageways to open ground. His head required eight stitches, but otherwise, he was all right.

Monte says his parents figured he was safer climbing into caves and abandoned mines than driving around with his friends, a popular activity in the 1950s. But today Monte adds, "My parents let me do things I don't think I'd let my kids do."

First Book Published Last July

The Handbook of Mineralogy, published last July, was a joint effort of four authors living in Ohio, Texas, Arizona, and California (Monte's home). Three of the writers, including Monte, studied under the fourth author, who is now a retired mineralogy professor from the University of Arizona.

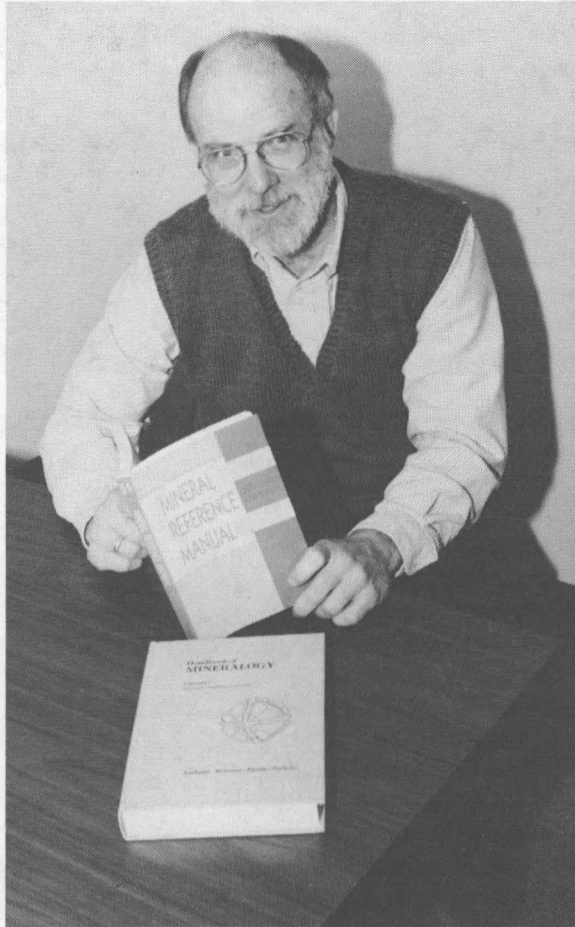
The team of writers began working on the handbook seven years ago. The first volume has 588 pages and covers the elements, sulfides, and sulfosalts. The second volume, which will have some 900 pages, is half complete and will cover silicate minerals. The third through fifth volumes

"We used carbide lights and would go a couple hundred feet down the mine shaft while Dad waited for us by the car."

will cover halides, hydroxides, and oxides; arsenates, phosphates, uranates, and vanadates; and borates, carbonates, and sulphates.

Monte says the five-volume set will be the most complete reference work aimed primarily at professional mineralogists, advanced collectors, material scientists, and libraries since *Dana's System of Mineralogy*, published about 40 years ago. At the time, only 1,500 mineral species were known; today, the number has increased to 3,700.

"This proliferation stems from several factors," notes Monte. "These are the continuing development of a firm base of physical and chemical theory for the crystalline state, the appearance of a wide array of remarkably sophisticated instrumental methods suited to the study of minerals, and the timely blossoming of computer science."



LOOKING OVER a paperback edition of the *Mineral Reference Manual* is coauthor Monte Nichols (8311). On the table before him is the 588-page *Handbook of Mineralogy*, which he also coauthored.

Entries in the book include information about each mineral's crystal data and physical properties. For example, some of the properties listed for gold are that it is "very malleable and ductile," "opaque in all but thinnest foils," "gold-yellow when pure, silver-white to copper-red when impure, blue and green in transmitted light." Other facts about gold include its cell data, luster, X-ray powder pattern, chemistry, polymorphism and series, occurrence, association with other minerals, and localities where it is found around the world. (Each mineral in the book has a separate page devoted to it.)

Monte helped design the book's cover, which displays a crystal design he created on his home computer. He also helped with typesetting and formatting. The book was published by one of the authors, who lives in Tucson.

Nichols and Nickel Make Book

The other book Monte helped write, the *Mineral Reference Manual*, is a joint effort with E. H. (Ernie) Nickel, a Canadian mineralogist now living in Australia. The paperback has 250 pages, is inexpensive, and is expected to be popular with both professional and amateur mineralogists, as well as material scientists and ceramicists.

"This latest effort came about after I met Ernie during a meeting of the International Mineralogical Association at Stanford a few years ago," says Monte. "We discovered that both of us were working on mineralogy computer data bases that we combined to produce a software reference work for the personal computer. We realized that no such listing of all 3,700 mineral species was available to mineral curators, professionals and amateurs."

The book was published in January by Van Nostrand Reinhold in New York. It is a compre-

hensive, easy-to-use reference manual. Its listings are alphabetical, a paragraph long, and contain information on the chemical formula of the mineral species, its appearance and density, the locality where it was first found, and several bibliographical references.

"We were able to complete this book in about a year because we had all the necessary information in our computer data base," Monte says. The

"We realized that no such listing of all 3,700 mineral species was available to mineral curators, professionals and amateurs."

MINERAL PC data base has been on the market for three years. Monte visited Ernie in Australia three years ago while giving a series of invited lectures on computed tomography and X-ray microfluorescence. Ernie is coming to California in June.

The two authors hope to update the paperback edition of the reference manual every four to five years, and they expect that 200 new minerals will be discovered before then. "Working with these teams has been good training for the team research I've been involved in at Sandia," Monte adds. ●BLS

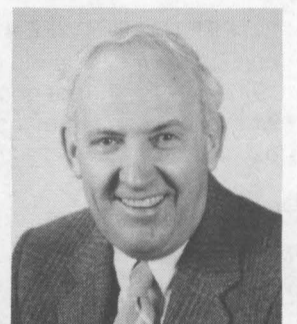
Congratulations

To Rita (2913) and Ed Hoak, a daughter, Amber Dawn, Dec. 12.

To Jennie (8171) and Bob (8513) LeBow, a daughter, Jamie Lynn, Dec. 6.

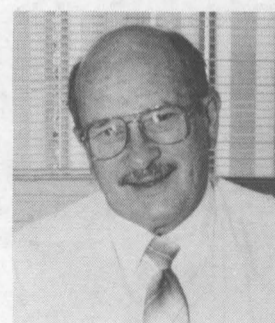
To Kari (8512) and Ben Neely, a son, Lee Michael, Jan. 14.

To Mary and Len (8435) Napolitano, a daughter, Carolyn Marie, Jan. 8.

Recent Retirees

David Dean
8133

31



Frank Duggin
8534

42



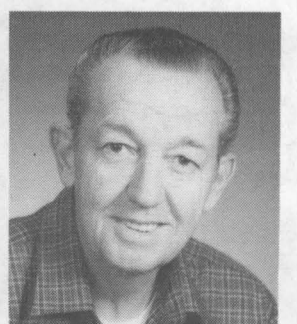
Mavis Flower
8524

27



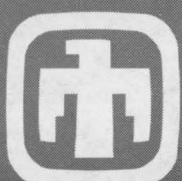
Tonni Nunley
8522

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Norm Toly
8271

32



**SANDIA
LIVERMORE NEWS**

(Continued from Page One)

Award-Winning Research

in a hydrogen atmosphere is a step in many micro-electronic-fabrication processes.

The results of treating defects with hydrogen can be contradictory, says Sam: "The effects are both good and bad. People have both exploited and lamented the hydrogen. If troublesome defects are electrically active, a hydrogen atom can go to a defect, form a bond with it, and passivate it [see "One Bad Atom in a Thousand"]. But it's also believed that if a silicon-dioxide-on-silicon structure contains hydrogen, it's more sensitive to radiation." Radiation sensitivity can be a problem for electronics used in weapons or in space.

"There's a lot of discrepancy in the technical literature on what hydrogen does to the radiation sensitivity of devices," adds Herman. "Our observations — particularly Keith's — and the theoretical modeling done by Pete showed that it's possible to explain why results in one case go one way and in another case go another way. It seems to depend on how much hydrogen goes to the interface — too much is worse than not enough."

Each of the four named in the award applied his particular expertise. Keith did experiments with electron paramagnetic resonance, concentrating on defects at the interface between silicon and silicon dioxide. Herman used infrared vibrational spectroscopy to study the binding and release of hydrogen and deuterium in the silicon dioxide. Sam used high-energy ion beam analysis as another way of observing deuterium in the oxide. (Deuterium is an isotope of hydrogen that behaves chemically like ordinary hydrogen but can be distinguished because it's twice as heavy.) Pete provided theoretical support, developing the theory of the kinetics and energetics of the hydrogen reactions. (See

Unless Hydrogen Meets Dangling Bonds

One Bad Atom in a Thousand Can Trash a Transistor

At a narrow frontier in nearly every microcircuit, silicon meets silicon dioxide. What happens at this frontier can determine how well a microcircuit functions, or whether it functions at all.

Virtually all transistors used in microelectronics include a thin layer of silicon dioxide (SiO_2) over a substrate of silicon (Si). In the SiO_2 , in the Si, and at the interface between them, defects exist in the material structure. In SiO_2 , for instance, each silicon atom is normally bonded to two oxygen atoms — that's what the chemical formula means. But sometimes a silicon or oxygen atom lacks one of its partners. The result: a dangling-bond defect. Because a dangling bond is electrically active, it can disturb the operation of the microcircuit.

Says Sam Myers (1112), "One of the most important defects in semiconductor technology is a dangling-bond defect at the interface between Si and SiO_2 . Our research has shown that this defect occurs when a silicon atom on the silicon side of the interface is bonded to three other silicon atoms, but has an unsatisfied bond at the interface. This forms the P_b center.

"It takes amazingly few of these defects to cause trouble with a transistor in a microcircuit," Sam continues. "If one silicon atom in 1,000 has this dangling bond, the transistor can have problems. Even one in 10,000 might be enough."

The effect of hydrogen is to "passivate" these defects. When a hydrogen atom links with the dangling bond, the bond becomes inert and is harmless to the operation of the transistor.

"Experiments and Theory Advance Understanding of Microelectronics Materials" for more on the work of each.)

Less Trial and Error

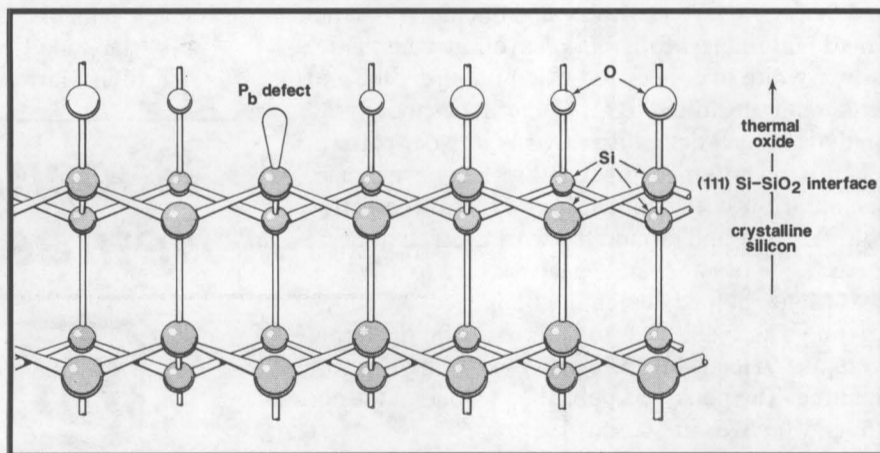
A likely contribution of all this Sandia work is to take some of the trial and error out of micro-electronic fabrication. Being able to predict what hydrogen reactions will occur, and under what circumstances, can help ensure compatibility with the other hundreds of steps involved in microelectronics processing. For instance, once the hydrogen treating has been done, it's important to know how much heat later processing steps can introduce without driving the hydrogen out.

The Sandia research also demonstrates another possibility: using hydrogen to passivate defects without heating. The conventional method, annealing the material in a hydrogen atmosphere, requires heating to several hundred degrees Celsius. But the Sandia group's theory and experiments show that a hydrogen plasma — which contains single hydrogen atoms as well as two-atom molecules — will passivate the defects even at room temperature. That's good to know, says Sam: "In semiconductor processing, to avoid heating is often very desirable."

The results of the research actually go beyond what can be used immediately. Sam interprets that as a sign that the new understanding of the processes is deep enough to yield benefits as yet unanticipated. "Some of the things we can predict in this complicated system may be of academic interest right now," he says, "but I think there's a good chance that they'll eventually have technological value as well."

In the meantime, the research on hydrogen reactions is extending into two further materials areas. One is the silicon in MOS microcircuits. The other is compound semiconductor materials, where hydrogen can influence the electrical properties in newer electronic and optoelectronic applications. Awards may typically mark an ending, but this BES award looks more like a beginning. •CS

INTERFACE BETWEEN silicon (Si) and silicon dioxide (SiO_2) — P_b defect occurs where a silicon atom has no oxygen atom to bond with.



Experiments and Theory Advance Understanding Of Microelectronics Materials

Discussing the research that won Sandia an award in DOE's 1990 Materials Science Research Competition, the four Sandians named in the award emphasize that it was what Sam Myers (1112) calls "a real mix of work."

A major result by Keith Brower (9221) came first. In the mid '80s, Keith observed experimentally a pair of small side bands in electron-paramagnetic-resonance spectra of silicon-dioxide-on-silicon samples. The side bands, which experimenters elsewhere had been unable to detect, confirmed the nature of the " P_b center" (see "One Bad Atom in a Thousand"). Keith estimates that the sensitivity of the EPR spectrometer he used was several times greater than that of most spectrometers. Built in the mid '60s, the Sandia spectrometer was gradually developed into a super-sensitive instrument capable of making the unprecedented observation.

Keith also credits Roger Shrouf (1112): "Roger grew literally thousands of oxide sam-

ples. Each one had to be done meticulously for reliable results. The signal-to-noise ratio in these experiments was marginal, which is why previous experiments hadn't been successful."

In the Oxide

The experiments done by Herman Stein (1112) dealt with hydrogen reactions in the silicon dioxide, rather than at the interface. When infrared light passes through the material, hydrogen atoms attached to either silicon or oxygen absorb some of the light's energy and vibrate like a weight on a spring. Depending on the mass — ordinary hydrogen or the twice-as-heavy deuterium — different infrared frequencies are absorbed. "I used isotopic substitution to study what the hydrogen does," says Herman, "showing that deuterium could displace hydrogen, or hydrogen could displace deuterium."

Sam Myers (1112) studied hydrogen in the oxide with a different tool. "If you have deu-

terons in there," he says, "you can send in a beam of high-energy particles of helium-3 [helium with two protons but only one neutron instead of the normal two]. When helium-3 interacts with a deuteron, a helium-4 is produced and a high-energy proton comes out. Basically, I was using high-energy nuclear physics to detect the particles in the oxide and see them moving around."

Pete Richards (1112) developed a theoretical model that would explain the experimental findings and allow prediction of behavior under different conditions. "I got involved about two years ago," he says, "after Sam had done a lot of his experiments. Basically, what I did was develop a theory that applied to the experimental situation. The experimental data was then fit to that theory to extract microscopic parameters — the microscopic-level binding energies — that allow prediction of how hydrogen will interact with these defects under various energetic conditions."

Quality In, Quality Out**Team of Quality Engineers Prompts Innovative Parts Partnership**

Sandia and three other DOE contractors have joined hands in an innovative quality improvement program similar to quality programs in Japanese industry. They hope to guarantee weapon component quality while studying the usefulness of a unique methodology for improving the way products are made.

The four DOE partners — Sandia, Motorola, Allied Signal's Kansas City Division (KCD), and the Alliance Companies — have formed a partnership, called the Quality Components Partnership, to implement this new methodology.

"Four engineers — two from Sandia and two from Kansas City — took the initiative and developed what is now a workable quality program for improving almost any product," says John Coffman (7321), project leader. "At first, it was difficult getting support for the project. But now we're hoping to pave the way for other partnerships of this kind."

An Idea Whose Time Has Come

The CQM methodology ("certification, qualification, and monitoring") incorporates the ideas of W. Edwards Deming, a US professor of statistics who traveled to Japan in the 1950s and took with him some new ideas for improving product quality.

Deming believed that the quality of the work necessary to build a product ultimately affects the quality of the product itself. Therefore, he said, the best way to improve the quality of a product is to formalize and improve the process that leads to the final product instead of weeding out "bad widgets" at the end of the process. Japanese industry adopted this theory, and Japan's growing economic strength and reputation for efficiency and product quality attest to its merits.

"A process that is stable and in statistical control presents a number of advantages," Deming said. Among these advantages are regularity, predictability, maximum productivity, and measurability.

Top-Rate Transistors

In August 1989, Sandians Laura Halbleib (7321) and John met with KCD engineers Steve Lumpe and Wade Davis to discuss how to improve the quality of transistors used in circuits designed by Sandia and assembled by KCD.

The transistors, used in programmers for certain attack missile systems, must be top-rate; failure of a single transistor in the field means possible weapon failure. Bad transistors equate to decreased reliability in the weapon stockpile, an uncertainty the US cannot afford.

When the group analyzed the process for designing, manufacturing, and assembling the circuits, they found that the four DOE contractors perform a total of 18 major tasks from the time a circuit is designed to the time it is assembled into a weapon subsystem — Sandia designs the circuits and writes initial specifications; KCD writes secondary specifications, orders the materials, and later builds the transistors into weapon subsystems; Motorola fabricates the transistors; and Alliance supplies materials and receives finished transistors for testing.

"All work is a process," says John. "We decided to concentrate on improving the process by breaking it into a series of manageable chunks, technical and administrative, each of which could be analyzed and measured statistically."

Measuring Stick

To evaluate each of the 18 steps, the group developed the CQM methodology (see "CQM: A Better Way to Make Widgets"), which assigns points to each task based on a set of standard, objective criteria.

Each step, technical or administrative, is analyzed to determine whether it is well-defined,

well-managed, capable of producing a quality product, and performed with some degree of regularity. Critical tasks in each step are evaluated even more closely. Each contractor's task is "certified" once a formal, measurable procedure has been established.

"Qualification" is a demonstration that each of the certified procedures is capable of contributing to a quality product. From writing a circuit's design specifications (the first step) to assembling the weapon subsystem (the last step), each step is assigned a baseline "score," on which further improvements are measured.

Finally, monitoring takes place so that continuous improvements in the process can be measured. Each step's statistical rating quantifies the degree of quality for that step. Once a quality process is established, John contends, product screening can be reduced because the materials and effort that went into the process will result in an improved output.

Janet Sjulín, Supervisor of Parts Quality Div. 7321, says there are a number of advantages in applying CQM to any process. The certification step, for instance, requires contractors to clarify their input and output needs for each other, which in turn encourages them to be more customer-oriented and to work together. Also, CQM specifically addresses performance, schedule, and cost criteria, the three defining characteristics of any quality management plan.

Mindset Shift

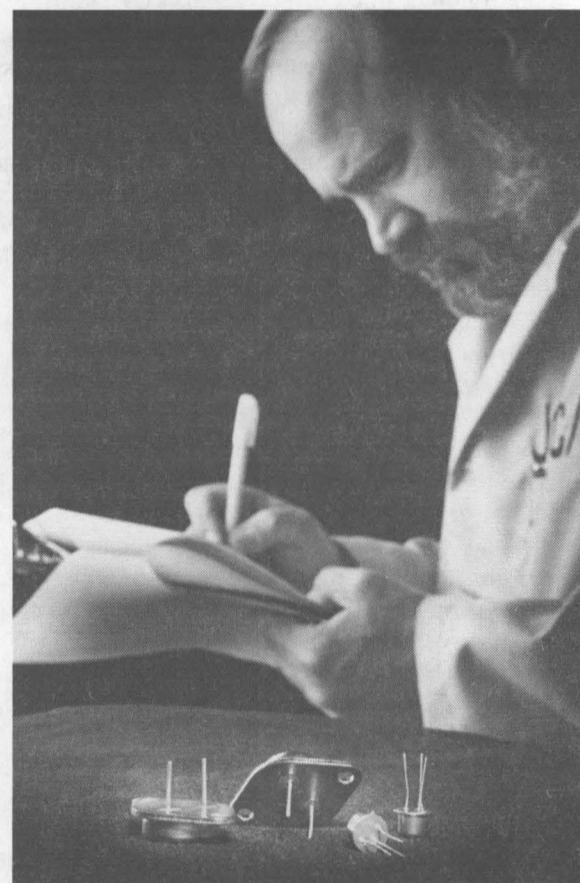
John says this shift from detection (screening out poor quality) to prevention (applying quality to an entire process) guarantees a quality product and is a good starting point from which to improve. "CQM methodology is a formalized procedure for measuring the quality of the entire process," says John. "Now we have a measuring stick for product quality."

The team, made up of representatives from each of the four contractors, is beginning to study how employees do their jobs at each step, which marks the beginning of the certification

process. All procedures should be certified by June, John says.

"Once we've certified the process for making these transistors, we've already certified the process for making other types of transistors," says John. "This pilot project will demonstrate that CQM can be applied to other processes as well."

For more information about CQM and its applicability to other processes, contact John on 5-8510 or Janet on 4-3157. ●JG



QUALITY IN, QUALITY OUT — John Coffman (7321) is one of four quality engineers (two Sandia and two KCD engineers) who developed CQM ("certification, qualification, and monitoring"), a new methodology for improving process quality. (Photo by Randy Montoya, 3162)

CQM: A Better Way to Make Widgets

Manufacturing any product, be it a high-quality transistor or a LAB NEWS story, involves a series of steps that are performed each time one of the products, or "widgets," is made. The sum of these steps is called a process. Some steps are administrative, such as filling out procurement paperwork for materials, and others are technical, such as assembling a widget.

The CQM methodology, short for "certification, qualification, and monitoring," examines each step in a process. Each step (subprocess) is evaluated and assigned a score based on the quality and formality of the procedures necessary for its completion and the quality of the management system that supports these procedures. Criteria used to evaluate these steps are similar to Malcolm Baldrige Quality Award criteria.

Manufacturing a simple widget, for example, may involve three subprocesses: writing the widget's specifications, ordering the widget materials, and making the widget. If CQM were applied to this process, each step would be evaluated by determining whether listed objectives formally address performance, cost, and schedule, and whether these objectives are communicated to the employees who actually write widget specifications, order widget materials, or make widgets.

Other questions address whether a plan for continuous improvement exists, whether critical operations in each step are performed regularly, and whether employees receive adequate training. Contractors' input and output requirements and each step's critical operations are also defined and communicated to employees.

Next, each step is assigned a maximum possible score based on a standardized, objective point system. The first set of criteria regarding the quality-management plan, for instance, is worth 250 points. The "defining requirements" set of questions is worth 40 points, and the "continuous improvement" section is worth 80 points. A score for a step might be 280, for example; this baseline score can be used to measure improvements later.

Once a process for making widgets has been certified and a baseline score has been established, widgets are tested to ensure that the certified process produces a quality widget. If it does, then the "qualification" portion of CQM has been satisfied.

Finally, the widget-making process is monitored to ensure that it produces quality widgets consistently and that the process improves continuously. The baseline score established in the certification phase is used to measure these improvements statistically.

Major Milestone Coming Up

Change Management Completes Start-Up Phase



Managing Change

As scheduled in Sandia's consulting contract with Being First, Inc.

(BFI), Sandia's change effort has successfully completed its start-up phase and is poised for a transition to longer-term issues.

"It's a significant milestone," says Dan Hartley, VP of Corporate Change Management Org. 5. "At our current rate of progress, we expect a smooth handoff of the lead consulting role from BFI to our own organizational effectiveness [OE] staff."

Completion of major start-up tasks was documented by a review team that looked at the tasks specified in Org. 5's contract with BFI. Some representative tasks:

- Develop and train an organization to manage the change process.
- Assist the Sandia Management Council (SMC) in defining primary outcomes for the change effort.
- Teach SMC and Large Staff how to manage cultural change.
- Define strategy for integrating major change initiatives.

"Although the formal BFI contract will continue to its planned termination date [July 31], the major tasks should be completed by the end of April," notes Dan. "When Sandia signed the BFI contract last summer, the change management group didn't yet exist, so SMC made a conservative estimate that it would take a year for a group of Sandia OE consultants to come up to speed. It looks now as if they'll be ready to take primary responsibility much earlier."

BFI will continue to be available to provide further consulting services to Sandia on an "as needed" basis.

Sharing the Credit

Credit for the on-schedule completion of major tasks is shared by both Sandia and BFI OE consultants.

"Dean and Linda Anderson [BFI principals] have provided us with practical approaches to help guide Sandia's change efforts," says

Berweida Learson, Operations Supervisor of Org. 5. "They've also trained us in the skills we need to help our customers apply these approaches to Sandia's major change initiatives, such as ES&H."

"Sandia's OE staffers have worked closely with the Andersons and the other external consultants," adds Dan. "I'm delighted at how quickly our people have come up to speed in helping the Sandians leading the various initiatives."

Org. 5's major consulting assignments (BFI associates in parentheses):

- Change Strategy — John Ledwith (Linda and Dean Anderson)
- ES&H — Elveta Bishop, Linda Logan-Condon (John Shannon)
- Quality — Susan Harris, Jo Ann Romero (Faith Ralston)
- Project Management — Warren Klein, Jo Ann (Becky Schreiber)
- Strategic Planning — Warren (Becky)
- Rewards and Recognition — Linda (Martin Marquardt)
- Change Ambassadors — Jo Ann
- Livermore — Linda (Sabina Spenser) ●BH

Teaming Up

Strategic Labs Alliance Gives Boost To New Mexico's R&D Complex

Recent successes of high-technology weapons in the Middle East, both offensive and defensive, could have a profound effect on the face of R&D in New Mexico. That's what Labs President Al Narath said Jan. 24 at a meeting of the heads of the state's three largest defense research laboratories.

During the meeting, the three labs — Sandia, Los Alamos National Laboratory, and the Air Force Phillips Laboratory (which specializes in space R&D) — entered into an agreement to collaborate on major research projects. This "strategic alliance" will help utilize the state's R&D expertise to its fullest and could help the labs attract new major R&D projects, said Ponziano Ferraraccio of the New Mexico Research and Development Group, a group that studies New Mexico's public and private R&D.

"The technology base that made high-tech weapons so effective in the Gulf War must remain robust and vital if it is to serve national security in the future," said Al. "But this technology base faces serious challenges, such as shrinking R&D resources and the rapid pace of foreign developments. Therefore, we must all

pull together and find common ground for cooperation and collaboration."

As benefits of the strategic alliance, Al listed pooling of core competencies, full utilization of the state's R&D resources, and efficient sharing of the state's technical expertise. Such benefits have already been realized by the alliance's first joint project — a four-year study of the Soviet Topaz II space nuclear power system (LAB NEWS, Jan. 25). Based at the University of New Mexico, the project will utilize the talents and expertise of UNM researchers in addition to those at Sandia, Los Alamos, and Phillips.

Other potential areas in which Sandia will contribute include radiation-hardened electronics for space and high-speed computing aboard spacecraft.

Other attendees at the alliance signing ceremony included Los Alamos Director Sig Hecker; General Ronald Yates, Commander of the Air Force Systems Command; Arthur Guenther, Gov. Bruce King's Science Advisor; and James Thompson, Dean of UNM's College of Engineering. ●JG

From Tokyo Institute of Technology

Bob Graham Receives Precedent-Setting Doctorate

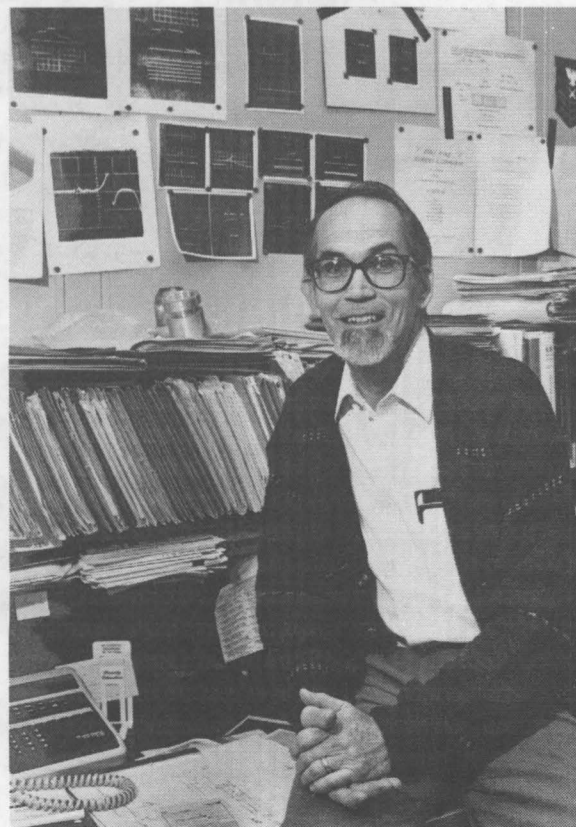
Some of the highlights of a 30-year career in shock-compression sciences are reflected by the instrument traces on Bob Graham's (1153) office wall. A different kind of highlight occurred recently, when he received the degree of Doctor of Science in Materials Science and Engineering from the Tokyo Institute of Technology.

Bob has never been a student there, but the degree isn't honorary in the sense usually understood in the US. In Japan, professional accomplishment is a recognized path to the doctorate.

However, the award of the degree to Bob does set a precedent: He is the first non-Japanese-speaking recipient. To complete requirements for the degree, he submitted a dissertation and passed language and technical exams.

"Of course it's a great personal honor," Bob says, "and I value it that way. Beyond that, though, it's important that the recognition comes from an academic environment for career accomplishments at Sandia."

"That reflects favorably on the research environment at Sandia, and specifically on the area I work in, shock-compression sciences." ●



BOB GRAHAM

Recent Patents To Sandians

Paul Eichel (9117), Dennis Ghiglia (1421), and Charles Jakowatz (9117): Phase Correction System for Automatic Focusing of Synthetic Aperture Radar.

Marion Scott (6258): Range Imaging Laser Radar.

Cecil Land (1164): Method of Bistable Optical Information Storage Using Antiferroelectric Phase PLZT Ceramics.

Bob Biefeld, Tim Drummond (both 1141), Paul Gourley (1143), and Tom Zipperian (1141): Semiconductor Devices Incorporating Multilayer Interference Regions.

Jan Allebach (Purdue Univ.), Don Sweeney (8435), and Ellen Ochoa (former Sandian): Optical Ranked-Order Filtering Using Threshold Decomposition.

Greg Frye (1846), Steve Martin, and Tony Ricco (both 1163): SAW Determination of Surface Area of Thin Films.

Rich Campiotti and Jim Hopwood (both 8284): DC Arc Weld Starter.

Carol Ashby (1126), Ron Hadley, John Hohimer (both 1164), and Del Owyong (1160): Semiconductor Laser Devices Having Lateral Refractive Index Tailoring.

Cecil Land (1164) and Ira McKinney (ret.): Method and Apparatus for Bistable Optical Information Storage for Erasable Optical Disks.



Labs Accomplishments FY90

Continuing a LAB NEWS feature begun 10 years ago, Laboratories Accomplishments FY90 sums up the principal achievements of Sandia National Laboratories during the fiscal year that ended Sept. 30.

The work summarized here has been submitted by organizations in Albuquerque, Livermore, and Tonopah. No attempt has been made to rank items, but an attempt has been made to group project-related items. The directorates that accomplished each achievement are shown in parentheses after each item.

Requests for further information should be sent to Public Information Division 3161, Sandia National Laboratories, Albuquerque, NM 87185-5800.

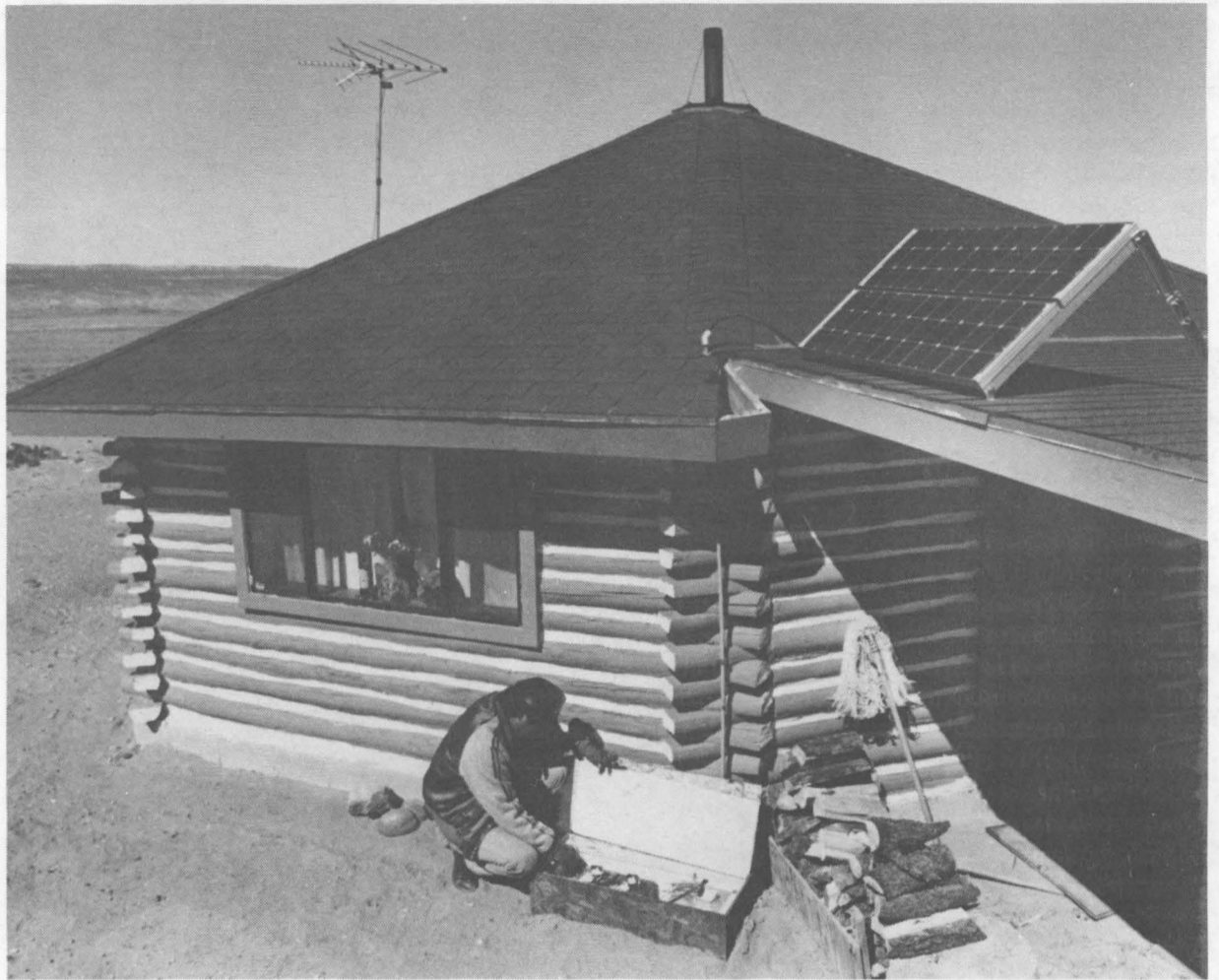
To All Sandians:

We have always taken great pride in our work and accomplishments. But we can be especially proud of our FY90 performance because we did some of the best work in our 41-year history, despite often distracting and difficult conditions, for example, budget uncertainties and a major effort to get our environment, safety, and health (ES&H) compliance program into full gear.

The 115 items in this annual Labs Accomplishments section show that we continue to render "exceptional service in the national interest," exactly what President Harry Truman requested in 1949 when he asked AT&T to manage Sandia.

As you read these accomplishments, you may notice that many of them credit more than one Sandia organization (org. numbers at end of each item). I think that's encouraging and indicative of the cooperation and joint effort between organizations that will play an increasingly important role in our future.

Al Narath
President



JASPER PABLO checks the storage batteries of a photovoltaic system for a Navajo home 10 miles east of Naschitti, N.M. (Photo by Mark Poulsen, 3162)



LAB NEWS

SANDIA NATIONAL LABORATORIES SPECIAL SECTION

FEBRUARY 8, 1991

Energy/Environment

- Sandia has provided **technical expertise in solar energy** to help Albuquerque install photovoltaic lighting systems for bus shelters and walking/biking paths; help residents in the Navajo Nation install photovoltaic lighting in more than 140 homes that never before had access to electricity; and help design a prototype photovoltaic power system for an AM radio transmitter near Tijeras that will be used by Cibola National Forest and the Albuquerque Convention and Visitors Bureau to provide information to travelers on I-40. Sandia's assistance will also help the state Highway Department operate and maintain 10 similar systems throughout the state. (6200)

- Joint experiments conducted by Sandia and Consolidation Coal Co. (Consol) quantified particle capture dynamics during **pulverized coal combustion**. The experiments used Sandia's Multifuel Combustor to simulate particle histories and the local environment inside large electric boilers. High-speed photography and particle diagnostics developed at Sandia were used to quantify the particles that stuck to a surface after impact (known as capture efficiency). This capture efficiency is a critical aspect of understanding and predicting ash deposition rates in pulverized coal combustors. (8300)

- Sandia demonstrated that three of the bulkheads at the Weeks Island facility of the **Strategic Petroleum Reserve** required upgrading in order to guarantee survival in the event of an accidental flooding. Non-linear stress analyses showed that two of the bulkheads need not be upgraded and that the repairs could be made for millions of dollars less than previously estimated. (1500)

- The **International Thermonuclear Experimental Reactor** project, a 1,000-megawatt experimental fusion power plant sponsored by the International Atomic Energy Agency, will feature design contributions and testing expertise from Sandia. The project encompasses work by engineers from the US, Soviet Union, Japan, and Europe. The conceptual design of the plant was completed this year. Specific Sandia contributions included design and high heat flux testing of divertor targets, new models of runaway electron generation, improved critical heat flux correlations, measurement and calculations of tritium in neutron-irradiated graphite, erosion studies in the D-III-D tokamak divertor, and analysis of residual stresses in graphite-to-metal braze joints. (6400/8300/1100)

HARRY HARDEE (6230-A) guides a cable connected to the In Situ Permeable Flow Sensor, which he designed with Sandy Ballard (6231) to monitor the direction of groundwater flow. The probe is buried near the Rio Grande in Albuquerque in a cooperative venture with the city to study groundwater resources. Similar probes were installed for a different purpose at DOE's Savannah River plant. Those probes have successfully monitored groundwater flow during a cleanup project to strip TCEs (trichloroethylenes) from the soil. Sandy and Harry are designing improved probes to be buried near the Rio Grande, and DOE has expressed an interest in installing more probes at the Savannah River site this year.



● Based on Sandia's investigation of the aquifers overlying the site, the Waste Isolation Pilot Plant (WIPP) has been accepted as a test case by an international group of hydrologic flow and transport modelers known as INTRAVAL. The three-year test process will help validate **hydrologic models for groundwater flow** through porous, fractured media. Meanwhile, a separate INTRAVAL study is examining and modeling observations of slow brine seepage in the underground salt beds at WIPP. The hydrologic model for the Culebra aquifer has shown that the presence of a leaky injection well could explain rising water levels a few miles south of the WIPP site. A recently completed study of the chemical, mineralogical, isotopic, and hydrologic nature of the Culebra aquifer indicates the regional water flow has changed direction during the last 10,000 years and is still in a transient condition. (6300)

● The first round of modeling of the **dissipation of waste-generated gas** from the WIPP repository shows that principal paths of gas dissipation are provided by higher-permeability interbeds sandwiched between the extremely low-permeability halite of the Salado Formation. The interbeds offer an opportunity for the gas to dissipate before pressures in the repository become too great to be contained by the rock. (6300)

● In collaboration with General Motors, Sandia completed the first **gas-phase temperature measurements in the wall boundary layer of an operating internal combustion engine**, using broadband coherent anti-Stokes Raman scattering (CARS). General Motors supplied a fast-response surface thermocouple gauge for making complementary heat flux measurements. The results will improve understanding of heat transfer in internal combustion engines and make it possible to produce better heat transfer models. The goal is to develop more efficient and cleaner-burning engines. (8300)

● In response to a DOE directive, Sandia designed a Mobile Instrumentation Data Acquisition System (MIDAS) for collecting and processing data from simulated accident scenarios involving **radioactive material transportation packaging**. MIDAS is the first instrumentation trailer specifically developed to meet Nuclear Regulatory Commission Quality Level I measurement requirements. Data from these tests assist the design, analysis, or certification of nuclear waste containers. In October, Sandia participated in a joint test with Germany's national agency for nuclear testing, in which researchers used MIDAS to provide high-quality experimental measurements used for certification of the Vitrified High-Level Radioactive Waste (VHLW) cask. As a member of the Science and Technology Alliance with other research institutions, Sandia also conducted educational demonstrations with the MIDAS instrumentation trailer at New Mexico Highlands University. (6300/7500)

● A **dial-up system of transportation codes** and databases known as TRANSNET makes information pertinent to the transport of hazardous materials available at no charge to approved users. The central code of the system is RADTRAN 4, DOE's radioactive material transportation risk assessment code, developed at Sandia. Popular features of TRANSNET include an interstate highway routing code and a database for radioactive materials incident reports. The StateGEN/StateNET software, also developed at Sandia, allows users to generate highway networks on their own personal computers and upload the information to TRANSNET, where it can be used to select routes based on Department of Transportation guidelines. Current users include federal agencies and their contractors, state agencies, university researchers, and private organizations such as the Gannett News Service. (6300)

● A new device, called the **In Situ Permeable Flow Sensor**, makes quick, accurate, three-dimensional measurements of the direction and speed of groundwater flow in a permeable medium using a thermal perturbation technique. The device, buried directly in the ground, helps characterize environmental waste sites and monitor cleanup efforts. A prototype of the device was successfully deployed at DOE's Savannah River site to monitor an innovative air-stripping operation to remove trichloroethylenes (TCEs) from the soil. Technology transfer is an important part of the overall effort: Two private firms have applied for and acquired non-exclusive licenses to develop the technology commercially. (6200)

● A new generation of **catalysts for converting natural gas** to liquid fuels and converting carbon dioxide, a greenhouse gas, to fuel are being developed using computer-aided molecular design (CAMD) methods. Sandia engineered the new catalysts with a cavity in their molecular structure that greatly enhances activity by promoting the binding of reactants by increasing the residence time of the substrate at the catalytic metal center. Synthesized at the University of California at Davis, the catalysts were characterized in experiments at Sandia. Sandia researchers predicted the structures of the catalysts with a molecular mechanics model that incorporated improved parameters for the molecular force field. The calculated structures agreed well with X-ray crystal structures produced at Brookhaven National Laboratory. (6200)

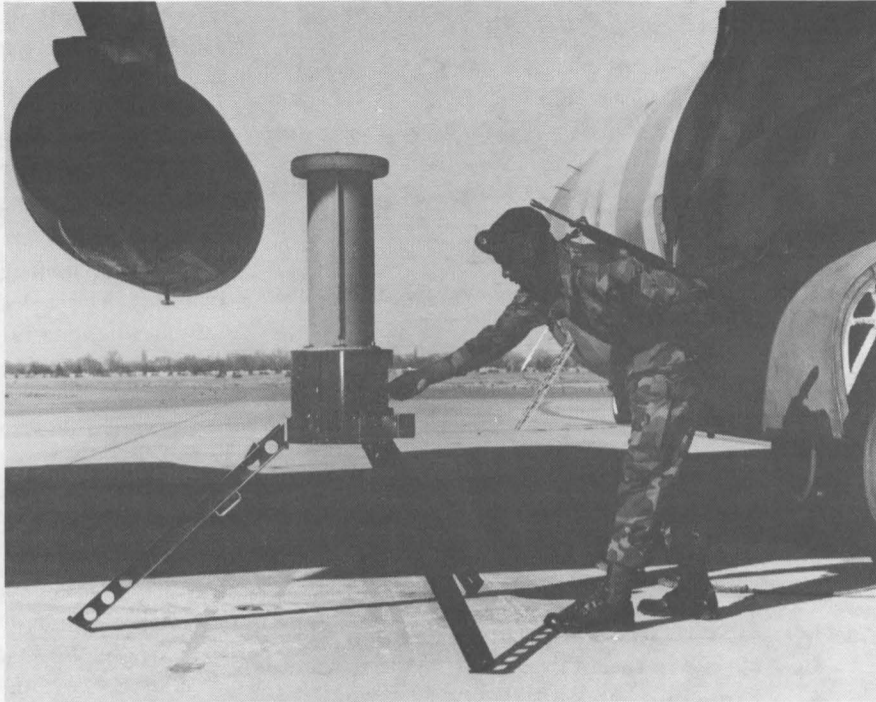
● Continued evaluation of the Yucca Mountain site in Nevada as a possible **civilian radioactive waste repository** led to development and review of 34 different configurations for the exploratory shaft facility (ESF). As part of the process, Sandia convened expert panels and designed a scoring system. Researchers also completed surveying and field mapping in preparation for exploratory trenching in nearby Midway Valley, and conducted Performance Assessment Calculation Exercises that evaluated the migration of radionuclides in several scenarios. Other accomplishments included a new program of cost schedule control and long-range planning. (6300)

● Researchers completed work this year on a project begun in 1976 to develop a **methodology for assessing high-level radioactive waste disposal** for the Nuclear Regulatory Commission (NRC). The methodology, used in radioactive waste management, is already known worldwide and has been adopted by other countries, as well as government agencies, universities, states, and private industry. Components of the methodology include nine computer codes that simulate groundwater flow and contaminant transport in different geologic surroundings, as well as techniques for dealing with scenario selection, uncertainty in data and parameters, and sensitivity analysis. The two most widely used computer codes are known as SWIFT and NEFRAN, and several versions of them have been developed. (6400)

● Sandia has developed a concept for **"caging" problem environmental sites** in a peripheral grid of directionally bored access conduits. This access will provide cost-effective characterization, monitoring, and remediation options not now available. Sandia has signed a three-year, no-cost development and demonstration agreement with Charles Machine Works, Inc./Ditch Witch™, a leading commercial manufacturer of shallow directional boring machinery. (6200)

Safeguards and Security

RAPIDLY DEPLOYABLE, pulsed-Doppler, range-gated monostatic radar sensor, called the Mobile Individual Resource Security System (MIRSS), protects military aircraft on parking ramps.

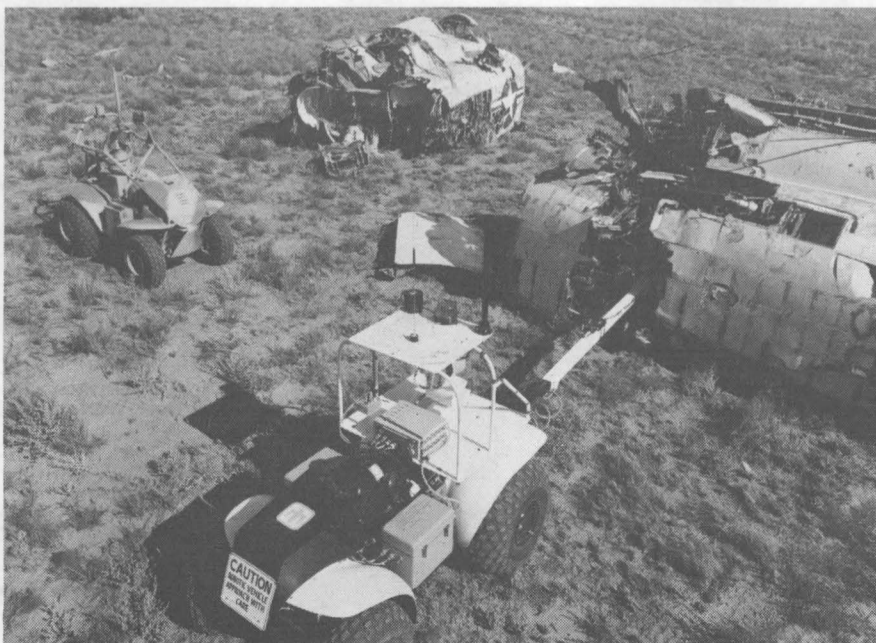


• Sensitive military aircraft on parking ramps will be protected with a rapidly deployable, pulsed-Doppler, range-gated, monostatic **radar sensor**. Called the Mobile Individual Resource Security System (MIRSS), Sandia developed the sensor for the Air Force Electronics Systems Division at Hanscom AFB in Massachusetts. Sandia is currently in the final phase of production of the first 40 MIRSS sensors. (5200)

• Technologies developed in Sandia's nuclear reactor safety program have been adopted and modified to produce new **probabilistic risk assessment (PRA)** techniques for evaluating nuclear weapon system design and safety. The techniques improve understanding of safety system technology and design and will be used to assess nuclear weapon system design and safety as part of the Labs' ongoing commitment to continuous improvement. (6400)

• Sandia demonstrated two unmanned vehicles equipped with video cameras that support **weapon recovery** following an accident. During the demonstration for DOE's Accident Response Group (ARG), all-terrain vehicles that had been modified for remote operation cooperated with each other to provide real-time video images to an operator and observers more than a mile away. The vehicles located and identified weapon parts and used the information to ensure safe handling procedures and accurate documentation of existing conditions. DOE/ARG is considering the use of unmanned vehicles. (5200)

RAYBOT (foreground) and Dixie (background) investigate the site of a simulated plane crash looking for nuclear weapons and parts. The operator is in a remote building.



• A **portable surveillance unit (PSU)** that provides a permanent video record of a monitored area is now available to private industry. Developed in support of the International Atomic Energy Agency's (IAEA) inspection directorate, the unit operates unattended for extended periods of time, recording visual images of the area under surveillance on dual recorders. The units are equipped with redundant recorders and security features to guard the integrity of the recorded data. The PSU is scheduled for field evaluation by the IAEA and EURATOM, the group responsible for all nuclear activities in the European Community. The PSU is commercially produced by MILETUS Associates of Albuquerque, selected by a competitive bidding process through Sandia's Technology Maturation Program. (5200)

• A new **portable intrusion detection system** uses a scanning infrared array to provide night-time security over a large, flat area. The operator's console and data processing equipment can be stored inside a van with sensors mounted on a 35-foot portable hydraulic mast. The system sweeps a 4-kilometer-wide area every 2 seconds, and relays long focal-length visual and thermal images to an alarm area for direct observation by operators. Completely passive, the system has a computer display and touch screen for producing situation maps and allowing operator input. The system could provide rapid security for mobile force concentrations or early warning beyond the normal fixed-site perimeter. (5200)

• Sandia designed, built, tested, and delivered a special-purpose transport vehicle to the Nevada Test Site (NTS) for **moving nuclear test devices** safely and securely inside the test site. The vehicle was designed to carry packages up to 8 feet wide, 10 feet tall, and weighing up to 20,000 pounds. The vehicle's cargo vault is designed to protect against ballistics and to delay theft attempts and can be loaded from the rear, side, or top. The transport vehicle can also be remotely immobilized. The protective envelope is a lightweight, modular armor developed at Sandia that can be easily constructed for different applications. The vehicle's design and operations were presented to a Nuclear Explosive Safety Study (NESS) group comprising representatives from several DOE offices and NTS. Final operational review of the vehicle is planned for March. (5200)

• Sandia participated in several studies and evaluations of nuclear weapon deployment for potential future concepts such as dispersing assets to alternate locations and being prepared to introduce or reinforce operations elsewhere. The goal is to increase the **survivability and security of non-strategic nuclear weapons** in the changing role of today's mobile nuclear forces. Sandia has identified various opportunities for improvement and continuing development. This project is being funded by the Defense Nuclear Agency and DOE. (5200)

• A new system that manages information on the security of **nuclear weapon storage** sites was delivered to Headquarters US European Command, Nuclear Surety Division. The system's database correlates all security requirement deviations and compensatory measures and permits quick preparation of status reports and graphs. Sandia expects to expand the system this year to manage additional kinds of information and electronically link storage sites with headquarters. (5200/2300)

• Technology for producing a fiber-optic seal has been transferred to the private sector. The **COBRA security seal** is currently being used by the International Atomic Energy Agency to seal spent nuclear fuel storage canisters in Canada and by the On-Site Inspection Agency for treaty verification purposes in the Soviet Union. The fiber-optic seal uses a commercially available, plastic fiber-optic cable that can extend as long as 30 meters. A modified still video camera and light source assembly reads the unique fiber-optic signature on each item. Sandia expects the COBRA seal to get much wider use as soon as the seals are commercially available. Aquila Technologies of Albuquerque provided the winning bid from among six potential suppliers to commercialize the seal and is now selling the product internationally. (5200)

• Sandia has developed new methods to predict the safety risk resulting from **shipment of nuclear weapon components** via DOE's highway transportation system. These analytical methods have been applied to actual shipment campaigns, and the results have been used in the licensing process for DOE weapon component movements. (5200)

• Modifications to the design of the Air Force Weapon Storage Vault were chosen as the best means of enhancing the security and survivability of **stored nuclear weapons** for Navy on-shore facilities. Preliminary work evaluated the requirements to adapt the existing design to meet Navy needs. The project was funded by the Defense Nuclear Agency. (5200)

Components/Materials and Processes

KIM MAHIN (8312, right) and Beth Fuchs (8243) prepare equipment for a welding experiment at Sandia, Livermore. The two researchers are involved in the use of sensors to measure temperatures and displacements in real time during gas-tungsten-arc and gas-metal-arc welding. The ultimate goals of new computer models being developed at Sandia are to eliminate the need for costly trial-and-error experimentation and to successfully predict the distortion, thermal history, and residual stress distribution in a weld. Computer and mathematical models of welding are complicated and difficult to develop because of the complex interaction between the arc (heat source) and the workpiece.



• **Non-halogenated solvents** have been demonstrated to be effective for cleaning weapon system components such as the W89 Firing Set. Increasing environmental, safety, and health issues associated with halogenated solvents prompted a study of alternative solvents. Current technology in the DOE Weapons Complex makes use of halogenated solvents for most cleaning processes. However, studies of cleaning efficiency, corrosion testing, bond strengths, and materials compatibility have shown a substitute cleaning solvent, the terpene, d-limonene, to be extremely effective. Allied-Signal's Kansas City Division is projected to begin using this solvent in cleaning processes for the W89 in February. (7400/1800)

• A privatization effort that will use the resources of private industry to produce **shipping containers for DOE** has resulted in development of the AL-SX shipping container for production. Sandia is providing program management as well as design, production, and procurement agency responsibilities. One of the major elements in the Labs' Purchasing Acquisition Plan was letting vendors know of the need for machining, inspection, and assembly services. Work continues on the development, documentation, and specification of the production process. (7400/7300/3700/5100)

• New precision etching and improved high-speed milling techniques developed at Sandia permit fabrication of state-of-the-art, high-performance microwave circuits. One such advance is a **spin-spray etcher** for use with ferric chloride to etch copper conductors on a commercial laminate substrate (Duroid™) with a degree of precision not commercially available. Sandia is capable of fabricating interconnection networks with line-width tolerances of

about 6 microns on a sheet of copper 17 microns thick and is capable of machining features such as slots, through-holes, and component relief holes that have dimensional tolerances of two-thousandths of an inch. (7400/2300)

• Sandia collaborated with the Rocky Flats production plant and private industry to develop a new system for **measuring current in resistance welding**. Devising an accurate system has been difficult because welding currents are so large and non-sinusoidal. Large sources of background noise associated with welding have also limited measurement accuracy. The new system uses a Rogowski coil to measure the time-rate-of-change of the weld current and integrates that signal to obtain the true current to within 0.1 percent accuracy for weld currents of 10 to 99 percent heat. Medar Inc. of Detroit plans to market the technology, which has been incorporated in resistance welding equipment at Rocky Flats and Sandia. (8200)

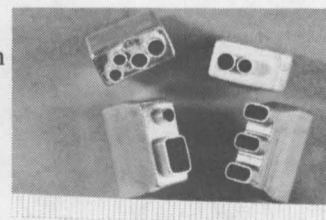
• Sponsored by the Defense Advanced Research Projects Agency, Sandia is collaborating with industry to develop and apply **intelligent process control** to advanced materials fabrication. Sandia and United Technologies have optimized a chemical vapor deposition (CVD) process for applying silicon nitride coatings to carbon-carbon composite structures. Sandia and Norton Co. are developing process models and control strategies to grow thick diamond substrates used in microelectronics packaging. In both programs, complex, chemically reacting flow models are incorporated into control algorithms and applied to CVD reactor design. Experimental diagnostics are used to measure process parameters, validate models, and develop process-control sensors. (8200/8300/1100/1800)

• A **rolamite inertial switch** substantially increases the nuclear safety of weapon systems in accidents. The rolamite has a rugged stainless steel housing and a band design that fails safely and predictably in abnormal shock environments. It withstands forces of up to 10,000 g's and temperatures up to 500 degrees F. A hermetic seal protects the silicone damping fluid from water contamination and eliminates the need for special handling. The new design is being incorporated into production of the B61-6,8 program and is being developed for the B90 program. (2500)

• New two- and three-dimensional numerical models coupled with improved measurement methods have significantly increased **understanding of the welding process**. Researchers used experimental data from the welding process, such as weld speed, amps, volts, and wire feed rate to generate numerical input for the analysis. State-of-the-art material models were used to evaluate stress and deformation histories in weld joints. Sandia researchers developed full-field, as opposed to point, measuring techniques to get better measurement of temperatures, weld movement, and weld metal transfers in real time. A 200-frame-per-second video system combined with helium-neon lasers and an optical filter recorded images of stationary and traveling welds. These images were digitally processed to enhance detail and reduce background noise. The increased knowledge is made possible through the integration of experimental data with the numerical simulation capability. (8200/8300)

• Sandia has developed a family of **radiation-hardened emulations of commercial microprocessors** and peripherals for use in space. The effectiveness of the single-event-upset hardening is such that the microprocessors have an upset frequency in geosynchronous orbit of less than once every 100 years, compared to a previously predicted upset rate of once every five days for the commercial versions. A single event upset (SEU) is a change in a single data bit caused by a cosmic ray colliding with a memory cell. The hardening is achieved with special emulations that have been applied to the Intel 80C51 Microcontroller and to the National Semiconductor 32C016 Microprocessor family, including the central processing unit (CPU), timing control unit (TCU), and interrupt control unit. The CPU and TCU are being used at NASA's Goddard Space Flight Center, and the CPU is being used at Caltech in the Mars Observer Camera program. (2100)

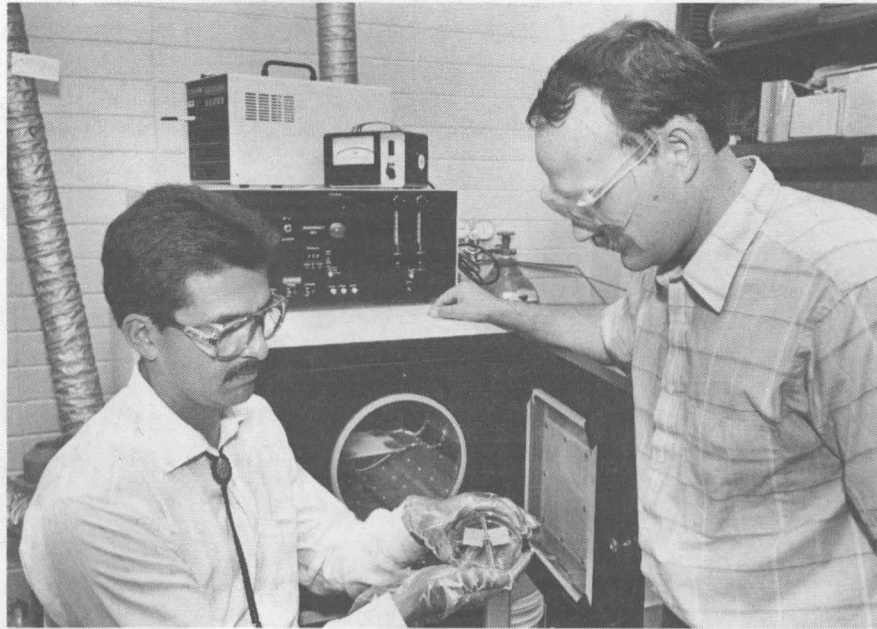
• Sandia has developed a **novel electroforming process** to fabricate connector shields for the W89/SRAM II telemetry system. The process involves copper electroplating and produces a part that does not require subsequent machining. Electroforming allows low-cost production of shield designs that could not be produced with conventional forming, welding, or machining operations. Use of these shields in the W89/SRAM warhead ensures high data fidelity in development and flight testing by eliminating noise during use. The program has been recognized for its low cost, low waste, reproducibility, and design flexibility, and is being applied throughout the nuclear weapon production complex. The US aerospace electronics industry has also expressed interest in the process. (8300/8400)



Connector shields made by electroforming.

Components/Materials and Processes

• Sandia's commitment to developing **environmentally conscious manufacturing** techniques for DOE's Environmental Restoration and Waste Management office has led to successful testing of replacements for halogenated organic solvents. Five alternative cleaning solutions, including aqueous-based cleaners and other organic solvents, were shown to have essentially the same ability as the halogenated organic solvents to remove resin-based solder fluxes from flat copper and soldered copper coupons. As part of the effort, Sandia also originated and publishes the *Environmentally Conscious Manufacturing Newsletter*, which disseminates information about environmentally conscious manufacturing processes gleaned from research and development, demonstration, testing, and evaluation projects at DOE facilities. (6600/1800)



ED LOPEZ (left, 1833) and Al Galuska (1823) examine copper coupons that have been etched clean with a plasma of ionized hydrogen and argon in the chamber behind them. The plasma removes copper oxides — an essential preparation before metals can be soldered — without using hazardous chemicals.

Technology Transfer

• Fourteen industrial companies, with guidance from Sandia, formed the **Specialty Metals Processing Consortium (SMPC)** and entered into an agreement with DOE to perform collaborative research. The purpose of the consortium is to improve the domestic technical base and protect the specialty metals industry, which is vital to national security and other industries such as aerospace, petrochemical production, and energy production. Sandia is providing facilities, employees, and management in support of the consortium. Research projects have been initiated in vacuum arc remelting and electroslog remelting. (1800/400/1500/8300)

• DOE and other federal laboratories are now adopting a database developed at Sandia for **tracking cooperative research and development agreements (CRADAs)** and licenses. The database generates such information as the number of private-sector jobs created by a CRADA and the percentage of a company's sales attributable to a CRADA, as well as statistical information needed for reporting purposes. Customers already using the database include Oak Ridge National Laboratory, Idaho National Engineering Laboratory, Argonne National Laboratory, Allied-Signal's Kansas City Division, and DOE's Albuquerque Operations Office. Copies have been requested by Solar Energy Research Institute, Lawrence Livermore National Laboratory, PANTEX, and DOE's Defense Programs. (400)

• Sandia has supported **SEMATECH** — an Austin, Texas-based consortium of integrated circuit manufacturers dedicated to restoring US competitiveness — in three major areas. In the area of equipment improvement, Sandia has applied its capabilities in reliability modeling, statistical analysis, software development, and ergonomics to improve equipment reliability and flexibility. In another area, Sandia has developed diagnostic devices such as process sensors for in-line manufacturing equipment control and for characterizing particle distributions generated by friction during manufacturing. In the third area, Sandia has developed numerical codes for modeling reaction chemistries and fluid flow in horizontal and single-wafer rotating disk reactors. Sandia has completed preliminary development of a selective tungsten process module. (2100/1100/-1500/1800/2300/6400/7200/7300/8200)

• Together with the University of New Mexico (UNM) Medical School, Sandia is developing a non-invasive monitor for **measuring blood glucose** levels in diabetic patients. The proposed method, which has been patented, applies multivariate statistical techniques to quantitative analysis of spectroscopic measurements made either through the ear lobe or web of the hand between the thumb and index finger. Preliminary tests have shown the method to be successful for measuring the glucose levels of blood samples taken with the present technique of pricking the skin, and calculations indicate sufficient sensitivity for future non-invasive glucose monitoring. Endocrinologists usually advise diabetic patients to take six blood samples a day to closely monitor their glucose levels, but because it is a painful, unpleasant process, patients do not always adhere to that schedule. (1800/UNM)

• A formal licensing program now expedites the **transfer of Sandia's patented technologies** and copyrighted materials to private industry. Transactions in 1990 have included the licensing of microcellular foam to Permcharge Corp. of Albuquerque as well as a solar tracking system to several companies: Power Kinetics Inc. of Troy, N.Y.; Kirk Enterprises of Inglis, Fla.; and Alpha Solarco of Cincinnati, Ohio. (400/4000)

• An **integrated circuit qualification program** called QUEST (Quality Enhancement Strategies) permits monitoring of the manufacturing facilities that produce radiation-hardened integrated circuits (ICs) for DOE and DoD. QUEST is a program that monitors the stability of the fabrication line process and the radiation hardness and reliability of integrated circuits. It is based on approximately 700 test structures and comprehensive parametric, radiation, reliability and circuit test programs, along with an integrated data analysis system. QUEST is an invaluable adjunct to DoD's QML (Qualified Manufacturers List), now being developed by the Rome (N.Y.) Air Development Center. In addition, Sandia has developed a family of transducer-laden IC chips that monitor corrosion, mechanical damage, electrostatic damage, mechanical stress, and contaminants during assembly and throughout the system's lifetime. Many industries have expressed an interest in applying this methodology. (2100)

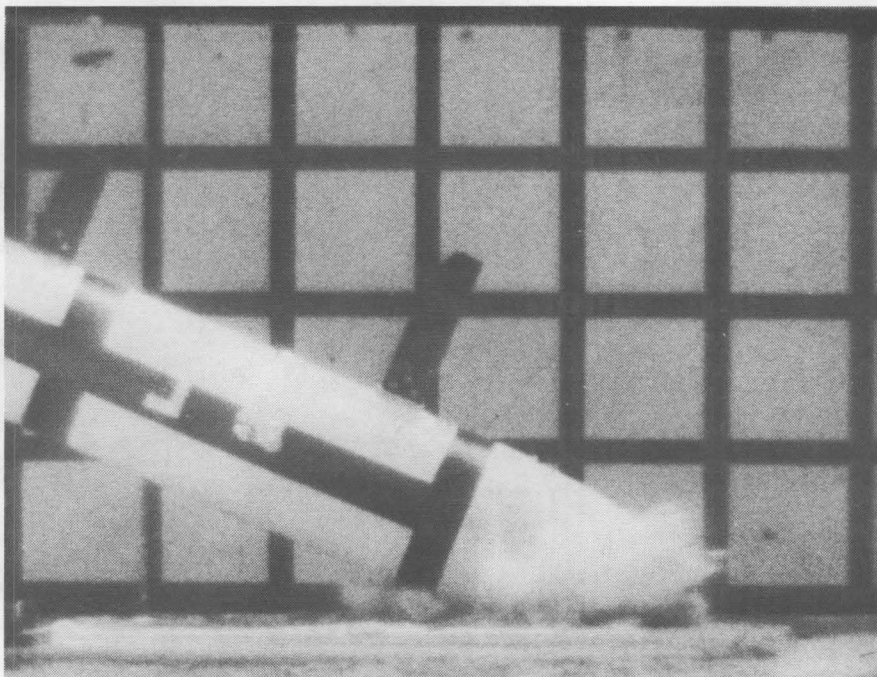
• Sandia is currently negotiating with a US company to commercialize an **advanced wind turbine** based on the design of the DOE/Sandia 34-meter Vertical Axis Wind Turbine, a research-oriented machine in Amarillo, Texas. A workshop in May promoted the formation of a joint commercialization agreement. The workshop audience included representatives of existing wind turbine companies, wind farm operators, manufacturing firms, aerospace firms, electrical power producers, and entrepreneurs. (6200/400)



ALEX MAISH (6224) keys data into a user interface board to check the performance of the Solar-Trak controller, an autonomous solar tracking system (in cubicle in center). The array tracks the sun in its path across the sky based on time readings and location rather than less reliable sun sensor data. The system is being manufactured and marketed by three solar energy companies that have negotiated non-exclusive licensing agreements with Sandia.

Nuclear Weapons

FREEZE-FRAME from a high-speed film shows the deformed shape of a B90 nose after axial impact. Though designers have been limited in the past by an inability to define nose loads, Sandia has developed a technique for reconstructing the dynamic force on the nose using accelerometer data obtained from actual impacts.



- An **energy-absorbing, crushable nose** is needed to successfully deliver a laydown bomb. Although designers have been limited in the past by an inability to define nose loads, Sandia has now developed a technique for reconstructing the dynamic force on the nose using accelerometer data obtained from actual impacts. Called SWAT, for Sum of Weighted Accelerations Technique, this technique has been extensively used to assess the performance of the B-90 Nuclear Depth Strike Bomb. The B-90 is delivered at high velocity from a low altitude, and a parachute is deployed to slow it before ground impact. The nose absorbs energy and limits mechanical shocks to the bomb. It is capable of performing the same function as previous nose designs with about 70 percent of the overall length and half the axial crush distance. (7500/5100)

- Phase 4 Production Engineering has begun for the modern, enhanced-safety **W89 nuclear warhead**, to be used with the Air Force's SRAM II standoff missile carried by the B-1B and B-2 bombers. W89 safety and use control enhancements include insensitive high explosive (IHE), fire resistance, modern nuclear detonation safety, permissive action link (PAL), and command disable. The W89 also includes an all-digital interface with the missile. DOE authorized Phase 4 last June following a readiness review that involved Sandia, Lawrence Livermore National Laboratory, and the production agencies. Sandia has supported production agency requests for pre-production activities related to tooling, gages, and materials procurement. Production is scheduled to begin in July 1993. (8100)

- A radiation-hardened, optically triggered **thyristor switch for tactical weapons** switches the large currents and high voltages required for firing set triggers, without being susceptible to premature triggering from transient radiation. The control terminal in the Sandia design is connected to a reverse-biased compensating photodetector that is shielded from the trigger light but produces a negative photocurrent pulse on the thyristor gate if it encounters X rays. This negative current keeps the thyristor from being triggered by internal photocurrents produced by the X-ray pulse, thus hardening the switch against transient radiation. (2500/1100)

- A **locking device for nuclear weapons** called the MC4164 Code Activated Processor Alternate (CAP Alt), part of the Permissive Action Link, went into production. The device is made with commercially available components and is a form, fit, and function alternate for the MC3764 CAP. It has cryptographic capability and can be configured to meet the command and control requirements of many weapons. (2300)

- A **massively parallel version** of a hydrodynamics shock physics code developed at Sandia (called CTH) has demonstrated that Sandia's NCUBE 2 and Connection Machine can outperform the best available vector supercomputer on nationally important hydrodynamics problems. CTH is being used extensively to analyze a broad range of problems, such as weapon safety and collisions between space debris and NASA space vehicles. Sandia has greatly increased its problem-solving capabilities through work with massively parallel computers. (1500/1400)

- Sandia received authorization in July to proceed with Phase 3 engineering development of the **W61 Earth Penetrating Weapon**. The W61 is a derivative of the B61-7 Laydown bomb. During Phase 3, a conversion kit will be developed and tested that will include a high-strength steel case to house carryover components from the B61-7, along with two new components that will be needed to interface with the delivery system. By using as many B61-7 components as possible, Sandia will minimize development time, reduce costs, reduce program risks, and provide improved capability. (5100)

- Sandia is developing a **composite weapon case** to replace the traditional steel case used on penetrating weapons. The new case would be used with the multi-role penetrator (MRP) now being developed for water, ice, and earth penetration and would reduce the overall weight of the weapon but maintain the same structural capability. Tests involving scale models and representative targets have been conducted at velocities of up to 1,500 feet per second to gather design data. Future plans call for more model tests followed by a full-scale demonstration test. (8100/8300/5100)

- The first formal **reliability assessment of the W88/Mk5** payload for the Trident II weapon system was published this year, summarizing extensive analysis of production and stockpile data. Communication between Sandia and Navy representatives has greatly increased the understanding of reliability assessment methodologies within both agencies. Both agencies have made hard decisions relative to production processes and testing to ensure the continued reliability of the nation's strategic deterrent forces. (7200/5100/2100/2300/2500)

- The firing set for the **Minuteman II** has been evaluated to determine its aging characteristics. The current results of tests of the past year indicate that continued stockpile life is possible. The study shows that technologies of past decades can be evaluated if needed. In this time of reduced weapon spending, recertifying older weapons will become important. (2300)

- Sandia's goal to continually improve the processes that assure nuclear weapon safety led to the preparation of a "**Weapon Nuclear Safety Assurance Plan**" for the Labs. The plan formally defines how safety requirements are determined and the means by which design features are incorporated to meet these requirements. The plan also addresses the independent review processes that assure the adequacy of safety features. The plan is based on a systems study of Sandia's weapon design and review processes, along with detailed recommendations from a multi-organizational committee chaired by the Systems Evaluation Directorate. (7200/2300/2500/2800/5100/-6400/8100/9300)

- Work continued during part of the year on the **Follow-On-To-Lance (FOTL)** warhead for the Army, with researchers completing Phase 2A Design Definition and focusing on nuclear safety, creation of a detailed project management structure, and a cost-vs.-benefit study. The FOTL warhead was designed to be compatible with the Air Force Short Range Attack Missile-Tactical (SRAM-T), with provision for a fuzing system, which Sandia was developing as a reimbursable project for the Army. Though the FOTL program was canceled in May, Sandia continued development of the FOTL Smart Environmental Sensing Device (SESD) for possible application in future programs. (5100)

PAUL HOOPER (5111) makes terradynamic observations following a high-velocity drop test of the W61 Earth Penetrating Weapon at the Tonopah Test Range.



Supporting Technologies

- Working with a consortium of companies, Sandia has contributed to a national effort to improve the productivity and worldwide **competitiveness of US industry**. The consortium is called PDES, for Product Data Exchange using STEP, the emerging international Standard for the Exchange of Product Model Data. The consortium, which includes advisors from Sandia, is working on a National Plan for Intelligent Product Definition that establishes the rationale and resources for achieving the group's goals. This initiative could significantly reduce the time it takes to introduce high-quality products at low cost and could yield direct benefits for DOE and private firms who deal with DOE. (2800)

- Sandia is using parallel computers to solve partial differential equations that depend on both space and time through an innovative method called **parallel time stepping**. Traditionally, such problems are solved using marching methods in which the solution is advanced sequentially in time: One step must be completed before another can be started. In that process, parallelism is limited to what is available in the space variables. However, Sandia's parallel time-stepping method overcomes this difficulty by solving at several time levels simultaneously. The new algorithm has achieved speedups of 857 on a 1,024-processor hypercube computer. (1400)

- A new edge-detection algorithm for **machine vision** applications developed at Sandia can distinguish shadow boundaries from abrupt object edges while being insensitive to image noise. This method addresses an important problem of industrial and safeguard vision systems — sensitivity to varying illumination. A spin-off of the method is that it also provides the first quantitatively successful theory on human perception of shadow boundaries. (1100)

- Sandia has discovered a new mechanism for the **diffusion of metal atoms** across metal surfaces. Direct observations of individual atoms have confirmed Sandia's theoretical prediction that migration on certain metals takes place by a process in which the diffusing atom replaces an atom on the surface. This mechanism is counter to the conventional picture in which an atom migrates by a series of atomic jumps. The observation of replacement diffusion on smooth surfaces at temperatures as low as 170 degrees K has important implications for crystal and epitaxial growth processes and provides a key insight as to how atoms may penetrate a solid surface in oxidation, corrosion, and alloy formation. The research is funded by DOE's Office of Basic Energy Sciences. (1100)

- The next-generation lithography tool for manufacturing extremely high-density microelectronics is expected to be **soft X-ray projection lithography (SXPL)**, a means of producing patterns for microcircuits. At Sandia, an SXPL beam line is being applied to advanced patterning studies aimed at developing this tool. The SXPL system consists of a 20-to-1 reduction camera that utilizes special surface coatings to enhance reflectivity of soft X rays. By decreasing circuit line widths to 0.1 micron, it will allow a 50-fold increase in packing density. The system is unique in that it uses soft X rays generated by a high-fluence laser plasma source. In 1990, the LPS facility won an R&D 100 award for excellence. The project is now a significant collaborative effort with US industry and universities. (8300)



"GROWING" SUPERCONDUCTING thin films on a substrate with an electron-beam evaporator are Tom Zipperian (back) and Thomas Plut (both 1141).

- Researchers have made significant progress in demonstrating the feasibility of an **optical firing system architecture** that may significantly improve nuclear weapon accident safety. Under a project known as Direct Optical Initiation (DOI), laser-based systems would replace electrical firing sets, using photonic energy transported over optical fibers to initiate detonation. Miniaturized rod lasers have been developed and demonstrated to survive mechanical use environments. Functional prototypes have also been developed for many optical components, including stronglink switches, laser-to-fiber coupling elements, high-power connectors, barrier feedthroughs, and slapper detonators. Progress has been made in understanding laser-induced damage mechanisms and contamination effects on optical components. A system demonstration is planned in early 1991. Continued efforts will focus on nuclear safety validation, miniaturization, radiation hardness, environmental robustness, material compatibility and aging, manufacturability, and application of the technology in other areas. (5100)

- Sandia's Primary Standards Laboratory (PSL) collaborated with the United Kingdom in comparing standards for **pulsed neutron calibrations**. The PSL maintains the US national standard. The work covered all US and UK neutron measurement systems under auspices of the Trident Warhead Projects Group and JOWOG 5. As one result, the US neutron standard was calibrated and confirmed as accurate by the UK's National Physical Laboratory, the equivalent of the US National Institute of Standards and Technology. (7300)

- A key series of experiments completed this year represent a significant advance in the **FALCON** program, a program to demonstrate the scientific and engineering feasibility of building a **megawatt-class, nuclear reactor-driven laser**. These experiments confirmed model predictions that a recently developed geometric concept can be volumetrically scaled to produce very high powers without sacrificing beam quality. This milestone will allow researchers to proceed in 1991 to a proof-of-concept demonstration test in Sandia's Annular Core Research Facility. (6400/1100)

- The **first high-temperature superconducting electronics** have been developed at Sandia in collaboration with the University of Wisconsin using the superconducting flux-flow transistor (SFFT). The SFFT's circuitry has the potential to surpass current technology in high-speed, low-noise operation. Sandia developed the materials, processing, modeling, and circuit technology for this new kind of electronics, and demonstrated and tested mixers, oscillators, phase shifters, amplifiers, and prototype digital circuit elements. Amplifier gains of more than 10 decibels at 4 to 5 gigahertz have been obtained, and mixer performance has been observed at frequencies of up to 35 gigahertz. (1100)

- A low-cost, computed tomography system that uses a personal computer and works much like a CAT scan has been developed for **non-destructive evaluation of parts and materials**. Various radiation sources, ranging from a 160-kilovolt microfocus machine to a 420-kilovolt source, may be used to produce images. The system can generate sectional views or cross sections of an object in two or three dimensions that show the density variation throughout the object. Spatial resolution has been achieved on the order of 100 microns with density variations of less than 5 percent. Researchers throughout the weapon complex have expressed interest in the system, and Sandia has transferred the technology to other agencies. (7500)

- **Several collaborators can participate** at the same time in a design session even if they are separated by great distances, using new software developed at Sandia. The software allows high-resolution graphics output from a Computer-Aided Design or other program to be simultaneously viewed and manipulated by people at several locations. This capability reduces the time needed for design iterations and technical explanations, as well as the need for travel and formal change paper. Based on the laboratory prototype, the software will be relatively inexpensive and will not require specific application modifications or elaborate database control mechanisms. (2800)

Other Defense-Related Work

- Sandia was asked by the Senate Committee on Armed Services to review technical issues related to the April 19, 1989, **explosion on the USS Iowa**. In the incident, an open-breech explosion of a 16-inch gun killed 47 crewmen. A Sandia advisory group reviewed the Navy's analysis of foreign materials in the projectile rotating band; analyzed the propellants to see if propellant stability was a contributing factor; and searched for possible gun mechanism abnormalities. While the team concluded that it could neither prove nor disprove the Navy's suggestion that a chemical igniter was present, team members demonstrated that the foreign materials could be explained by the operational environment; that powder stability was not a causal factor; that the powder bags had been overrammed into the seated projectile; and that pellets in the "trim layer" may fracture during impact loading, producing burning particles that can ignite the adjacent black powder bag (the "trim layer" is an incomplete layer of pellets lying on their sides). The Navy later demonstrated Sandia's trim layer predictions to be true in full-size impact tests. Sandia presented its conclusions in testimony before the Senate Armed Services Committee. This presentation included a scenario in which an inadvertent overram may have been the cause of the explosion. (2500/1100/1500/1800/6400/7200/7500/9100/9300)

- Sandia has made significant contributions to miniature **synthetic aperture radars (SARs) and image recognition systems** that operate in all weather, day or night. These efforts hold promise for precision weapon delivery, verification, and surveillance systems. Proof of principle tests are being flown in a DOE Twin Otter Aircraft. Funding is being provided by DOE and DoD. (9100/2300/7500/1400)

- At the request of DoD, Sandia appraised the relative merits of the **Multiple Launch Rocket System (MLRS)** and the 8-inch, self-propelled howitzer by using a Cray-YMP supercomputer and the SCABBARD computer code developed at Sandia for warfare simulation. Using detailed models of terrain, military traffic, battle strategy, and munition lethality, a Sandia team concluded that a three-launcher MLRS platoon is as effective as an eight-gun battery of 8-inch howitzers for reinforcing an Army Mechanized Brigade. As part of the simulation, previously unavailable procedures were developed for approximating the lethal areas of conventional munitions in forested and urban environments. The project was funded by DoD. (8100)

- Sandia has developed an **ice-penetrating sensor (IPS)** for advanced torpedo applications. The IPS is an air-delivered system capable of deploying a hydrophone underneath an ice layer for underwater surveillance in the Arctic region. Sandia has conducted several air-drop, ice-impact tests of mechanical prototypes in the Arctic region equipped with instrumentation for characterizing the shock that the IPS electronics would experience. The sensors can be used to guide torpedo systems in locating submarines. (8100/5100)

- Sandia has continued to pioneer the design of **Electronic Safing, Arming, and Fuzing (ESAF)** technologies for advanced conventional weapons. These systems draw heavily on Sandia's experience with nuclear weapon components and offer major improvements in reliability. The Army, Navy, and Air Force all supported this work at Sandia during 1990 for such systems as AMRAAM, Patriot, and the Advanced Bomb Family. (9100/2300)

- The **Sandia Airborne Computer (SANDAC)** has several new capabilities that have greatly increased its speed and versatility. A new prototype of a Motorola 68040-based processor module has the equivalent computational output of at least five of the Motorola 68020-based processor modules now being used. Because SANDAC can incorporate up to 15 processors, this processor greatly broadens the scope of SANDAC applications and reduces the size of airborne computers used for existing applications. Another capability is the use of Sundstrand disks for loading software automatically, allowing users to develop and store software on personal computer disks and permitting non-users to load mission-specific software more easily. Finally, a third capability supports Ada language programming needed for DoD applications. (2300)

- Researchers successfully flight-tested a **Video Imaging Projectile (VIP)**, an electronically instrumented 155-mm artillery shell designed for short-range reconnaissance. Two firings of the VIP yielded television-quality pictures of ground features at the Tonopah Test Range. VIP was launched on a flattened trajectory at a height of about 3,000 feet. Roads, vehicles, and other ground features were easily discernible in the radio-broadcasted images taken by the projectile. An on-board telescope and single photodiode generated the pictures by taking advantage of both the spin and forward motion of the projectile to produce a raster-scanned image of the ground. (8400)

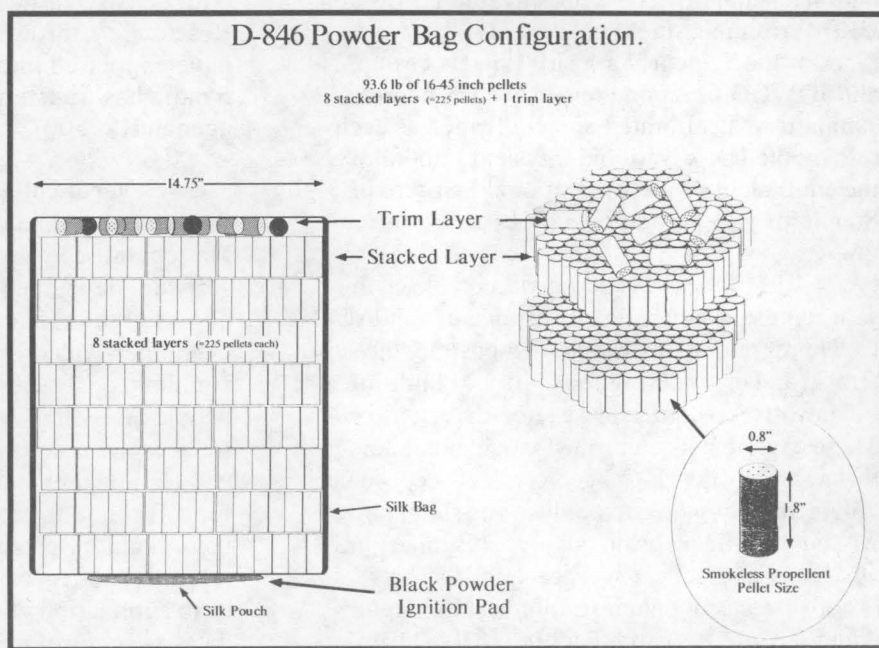


DROP TEST SETUP is checked out by Karl Schuler (left, 1544) and Paul Cooper (9333). The cylindrical stack behind them is formed by weights that determine the energy of impact.

- To aid in the "real-time" precision **tracking of reentry vehicles**, Sandia developed a special microstrip antenna and ballistic missile translator/power booster system. The unique antenna design afforded near-constant amplitude (strength) and phase reception (timing) of signals generated by a Global Positioning System satellite over approximately 90 percent of the spherical volume surrounding the missile. Stability of the amplitude and phase are critical parameters that make it possible to determine the precise position and velocity of the reentry vehicle during flight. This system provided the desired tracking precision in several missile flight tests at the US Army Kwajalein Atoll (USAKA), using both ICBM trajectories and sounding rocket trajectories. The demonstration is a first step toward improved USAKA instrumentation and accurate target tracking, and it is a methodology for accurate weapon delivery. Funding was provided by the US Army Strategic Defense Command. (9100/2300/5100)

- Sandia developed and flight-tested three reentry vehicles for the Air Force to investigate new technologies for **maneuvering flight reentry vehicles** under a program called MaST (Maneuvering Systems Technology). Two new nosetip materials and several potential antenna window materials and designs were tested. Two of the vehicles had antenna systems for measuring the effects of plasma on radio-frequency signals generated both on board and off board. This test provided the Air Force with its first high-quality plasma-related data at angle-of-attack for the design of future antenna systems. The third vehicle was recovered while in flight at a low altitude in order to observe the effects of reentry heating on the nosetip and antenna windows. The recovery was a success and was accomplished by jettisoning mass and using two-stage drag flaps to slow the vehicle down. Sandia is the only organization that has successfully recovered a high-performance reentry vehicle. The Air Force Ballistic Missile Organization provided the funding for this program. (9100/1500/2300/5100/7400/7500)

POWDER BAG of the type being used on the USS Iowa when a 16-inch gun detonated prematurely. The bags of propellant are about 15 inches across and consist of some 1,800 pellets neatly arranged parallel to each other in eight stacked layers, plus a trim layer of pellets on top on their sides to bring the bag up to the specified weight.



Other Defense-Related Work

- Sandia completed flight qualification of inertial navigators for the **Strategic Target System (STARS)** and delivered systems for the ground test missile and the first flight test. Design, development, fabrication, and flight test preparation have also been completed on a new three-gimbal system to be used in experiments in synthetic aperture radar (SAR) imaging. The gimbal system incorporates a controller based on AT&T's DSP32C digital signal processor and Sandia's newest miniature ring laser gyro inertial measurement unit (RLGA) for navigation, pointing, and image stabilization. (2300)

- The **Terrier-Malemute rocket system** launched at NASA Wallops in Virginia helped produce the first laser observations of a decoy target being inflated and controlled in space. Funded by the Strategic Defense Initiative Office in support of a program called FIREFLY, the project included a Sandia payload controlled by ground command that was thrust after a decoy target that had been ejected into space in a prescribed direction. The target's motion was monitored by a television video in the payload. Meanwhile, a laser radar 750 miles away at the Massachusetts Institute of Technology tracked first the rocket and then the target, producing the laser imaging. (7500)

- Major improvements in **light-gas gun technology** have resulted in the launching of gram-size plates to velocities exceeding 6 1/2 miles per second. This technology has allowed Sandia to evaluate debris shield designs for the space station Freedom, a NASA project to put a permanently operating laboratory into Earth orbit, and is creating new opportunities for dynamic testing at previously unachievable velocities for other government agencies and industrial laboratories. (1500)

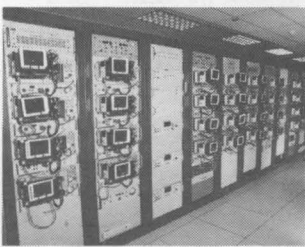
- A four-year program to understand how missile boosters respond in a pulsed laser attack and the consequent impulse produced on the missile's exterior culminated in a major experiment in 1990 that involved subjecting a functioning rocket motor to an explosively delivered, side-on impulse load. When the motor case burst open, it provided compelling support for the hypothesis that **shock damage inflicted on the solid propellant** precipitates catastrophic overpressures in intercontinental ballistic missile boosters. The strain, thrust load, photometrics, and internal pressure response of the motor confirmed the behavior predicted by Sandia's analytical models. The results will significantly reduce the lethal impulse levels that past assessments have assigned to this kind of target and will have a bearing on vulnerability analyses of missile systems. (8200/7500)

- A Sandia demonstration showed that pressure oscillations can be eliminated during the **combustion of liquid propellants**, now being evaluated by the Army for use with large-caliber guns. The project is funded by both DoD and DOE. A major impediment to the use of liquid propellants has been concern that high-frequency pressure oscillations may seriously shorten the lifetime of a gun or damage sensitive, electronically "smart" munitions. Using a specially designed injector/combustor apparatus, researchers eliminated oscillations with a flexible gun liner and dramatically reduced oscillations with a jet splitter gun attachment. These devices are being reviewed for adaptation to the 155-mm liquid propellant gun being developed by General Electric for the Army. (8400)

- A **highly parallel version** of a three-dimensional code for simulation of time-dependent fluid motion on the NCUBE 2 hypercube computer has applications for underwater acoustics, turbulence studies, and geological convection. Performance for the computationally intensive portion of the solution algorithm has been measured in excess of 1.5 gigaflops on each of the hypercube's 1,024 processors. The code is an incompressible parallel Navier-Stokes solver that provides a unique capability to perform large-scale simulations involving more than 10 million grid cells in the computational domain. (1400/1500)

Testing

- A wide-band, analog **fiber-optic data link** is being phased into Sandia's instrumentation at the Nevada Test Site. The link consists of solid-state, 1,300-nanometer laser transmitters that drive approximately 7 kilometers of single-mode optical



High-frequency test racks.

fiber to receivers and recording instruments. The links offer up to 3,000 megahertz band width, greater than 100-to-1 dynamic range (400 to 1 is typical), electrical isolation from input to output, and immunity to electromagnetic

pulse effects. This system allows oscilloscopes and digitizers to be permanently installed in a centralized recording room (reducing fielding time and the number of operators) away from the harsh underground environment. The system currently has a capacity of more than 140 channels. While no other agency yet has a similar facility, Sandia is working with the Defense Nuclear Agency to transfer this technology to other testing agencies. (9300)

- Sandia-designed closure systems, the Fast Acting Closure (FAC) and the Gas Sealing Auxiliary Closure (GSAC), contributed to the success of the MINERAL QUARRY **underground nuclear weapons effects test**. In addition to the standard radiation and containment diagnostics, Sandia fielded a low-photon energy spectrometer in support of an Army experiment. Several innovations in quality control and project management made Sandia the first agency to be prepared for all significant test activities. Sandia recorded data from the following experiments: advanced reentry vehicle coatings, calorimeter and strain gage recording improvement, stress gage development, slow total fluence calorimeters and neutron diagnostics, and earth motion and pipe diagnostics. (9300)

- Advanced space systems rely heavily on complex electronics to fulfill their mission. However, a collision between a single high-energy cosmic ray and sensitive portions of a satellite's electronics can disrupt the satellite's computer functions; this is known as a single event upset (SEU). Sandia has developed an imaging technique that identifies the upset-prone regions of integrated circuits (ICs) before they are used in satellites. This **ion microbeam imaging**

technique generates micron-resolution maps of where SEUs occur by irradiating, in isolation, the lowest functional units of an IC and immediately measuring the effect of the high-energy ion strike on circuit performance. This capability is currently unique to Sandia and provides new and important information for designers of radiation-hardened microelectronics. It may also have an impact on the software design of space-borne systems. (9300/1100/2100)

Environment, Safety, & Health

- A special **Hazardous Materials Task Group** reviewed and evaluated all hazardous expendable materials authorized for use by nuclear weapon technical publications. During the review, the group deleted 120 hazardous materials from a total of 261 listed in the publications and developed new procedures that comply with ES&H regulations for handling materials and processes still authorized for military use. In addition, the task group completely updated and revised publication TP 35-51, "General Instructions Applicable to Nuclear Weapons." The task group also established a hazardous material database for identifying and tracking materials used in weapon programs. (7200/5100/8100/3200)

- Sandia trained 1,000 people in FY90 in the handling of hazardous waste and developed "**Guidelines for Hazardous Waste Generators.**" Classes are tailored to the needs of each organization; instructors visit lab sites before each class. Dramatic improvement was demonstrated when an audit by the state of New Mexico found no violations in organizations whose employees had received training. (3200)

- **ES&H awareness** at PBFA II has brought a sobering realization of the changes that must be made. Last spring, PBFA II was used as a hands-on site to train so-called "tiger cubs." The experience resulted in a seemingly endless four-week suspension of activities. The application of Sandia's commitment to excellence to ES&H requirements will require strong medicine, but the curative is not so much in the form of adaptive policies and practices as in a heightened awareness of the concerns that motivate the policies. A positive outcome of the ES&H experience is that it has improved efficiency and led naturally into Sandia's Quality Improvement Initiative. (1200)

- Sandia's Tech Area III and Tonopah Test Range's Station 3 are getting **new sanitary sewer systems**. Design work is complete and construction is complete or under way. In Tech Area III, the new system will replace 45 septic systems. The system will have 60,000 feet of pipe and will serve the south side of Kirtland Air Force Base. The Tonopah system includes 5,000 feet of sewer lines that will be connected to all facilities. (7800)

Arms Control Verification

JOHN TAYLOR, Verification Systems and Technology Division 9241, looks over a scale model of an INF-treaty verification facility operated by the US in Votkinsk, USSR. This model, along with others located in Bldg. 855, helps US government officials make decisions regarding verification of treaty agreements. The signing of the Conventional Armed Forces in Europe (CFE) Treaty by NATO and Warsaw Treaty Organization countries provides new challenges for monitoring treaty compliance. Sandia has led the nation in developing training programs and preparing for on-site inspections by Soviets at US sites.



• The signing of the **Conventional Armed Forces in Europe (CFE) Treaty** by NATO and Warsaw Treaty Organization (WTO) countries has moved the world beyond the bilateral agreements of the past between the US and the Soviet Union. This new multilateral treaty provides new challenges for monitoring treaty compliance, and tens of thousands of items will need to be monitored, although no weapon systems will be completely eliminated. Sandia, working with Lawrence Livermore, Los Alamos, and other national laboratories, conducted a Verification Framework Study of the CFE for DOE's Office of Arms Control. The study identified monitoring technologies that could be applied to the treaty as well as research into emerging technologies. Sandia has also begun work on a computer system to manage WTO and NATO data. (9200)

• Sandia has led the nation in developing training programs and preparing for **on-site inspections (OSI)** by Soviets at US sites, including participating in and directing several inspection exercises. Because of agreements limiting strategic nuclear weapons and chemical weapons, OSI may affect more and more government and private facilities. Sandia evaluated the potential effect of several treaty mandates on activities at Albuquerque, Livermore, Tonopah, and various Air Force bases, and found several challenging national security concerns. Hosting such an inspection would be logistically complex and preparations could become expensive. Sandia is continuing its analysis in support of DOE's evaluation of OSI, and has been asked to provide several executive agencies of the US government with briefings on its findings. (9200)

JOURNALISTS FILM a tank being equipped with a reflective tag that identifies the vehicle, similar to the way a fingerprint identifies a human being. The tags have a unique pattern of tiny, crystalline particles and can be used for treaty verification.



• Since the early 1960s, Sandia has been involved in the development of **advanced seismic technology** to verify underground nuclear test treaties. This technology is a key part of the Designated Seismic Stations (DSS) that will be deployed to verify the recently ratified Threshold Test Ban Treaty with the Soviet Union. The DSS program was initiated in the fall of 1990, and these seismic stations will be available for deployment in the Soviet Union in 1991 to monitor selected Soviet tests. During each test, three stations will collect seismic data at regional distances, where additional seismic phases will improve the yield estimates over those that have been possible in the past. (9200)

• The amount of human intervention needed to process and utilize data, especially large quantities of data with complicated numerical codes, can be reduced with a **generic expert system (ES)** developed at Sandia to evaluate seismic array data in test ban treaty applications. The ES performs three functions — it manages data, analyzes data, and accepts new information and modifications. The first function aids in building a database; the second allows the analyst to define the calculations to be performed and examine the results (the ES invokes all the required numerical codes and compiles the results); the third function adapts to the changing needs and questions of the analyst. The ES's format makes it easy to apply to different problems. The Air Force recently provided funds to Sandia to apply the ES to analysis of nuclear detection data from satellite sensors. (9100/6200/9200)

• The five Global Positioning System satellites launched during the past year were equipped with **Nuclear Detonation Detection System** payloads designed at Sandia. When the 24-satellite constellation is completed in early 1993, the NDS payloads will provide continuous, worldwide, real-time detection and location of nuclear detonations. Combined with data acquisition and display systems designed at Sandia, the NDS will be used to verify the limited test ban treaty and to report nuclear strike information in the event of nuclear war. (9200)

• A **Phase Gradient Autofocus (PGA)** technique developed at Sandia received both a patent and an R&D 100 award in 1990. The PGA automatically focuses images from a synthetic aperture radar (SAR). Without this technique, SAR images can be extremely blurred. Compared to previous methods, PGA produces superior results and is easier to use on a general purpose computer or customized hardware. Applications include radar reconnaissance and imaging sonar. Potential applications include sonar beam-forming and seismic analysis. (1400/9100)

• The **Reflective Particle Tagging** system, developed at Sandia for DOE's Office of Arms Control, has been accepted by the federal government for potential use in the treaty verification program. Tagging distinguishes legal from illegal items limited by the treaty. The Sandia system consists of a non-counterfeitable and non-transferable tag made of a mixture of clear plastic and small reflective particles applied to items such as missiles. The random three-dimensional pattern of the reflectors can be read like a fingerprint to ensure that the items to which they are attached are the original items allowed by the treaty. (9200)

Pulsed Power Development

- Sandia produced a 100,000 joule, high-purity lithium ion beam of 8 to 10 megavolts for 15 nanoseconds on its **PBFA II** (Particle Beam Fusion Accelerator II) fusion research facility during 1990, meeting many of the objectives proposed by a National Academy of Sciences review panel. During proton beam experiments conducted on the facility, Sandia also achieved a gross azimuthal beam uniformity of 10 percent and increased the insulating magnetic field to a record 5 tesla for ion diodes, making it possible to operate at higher voltage and to test beam divergence predictions. (1200)

- Sandia has greatly improved the understanding of **ion beam divergence** caused by electromagnetic fluctuations in applied-B ion diodes — a major problem limiting the power intensity and energy available in Sandia's Inertial Confinement Fusion Project. Analytic theory along with three-dimensional QUICKSILVER computer simulations and experimental data have provided a physical picture of instabilities in these devices. Researchers have developed several ideas about how to reduce this divergence and improve diode performance. (1200)

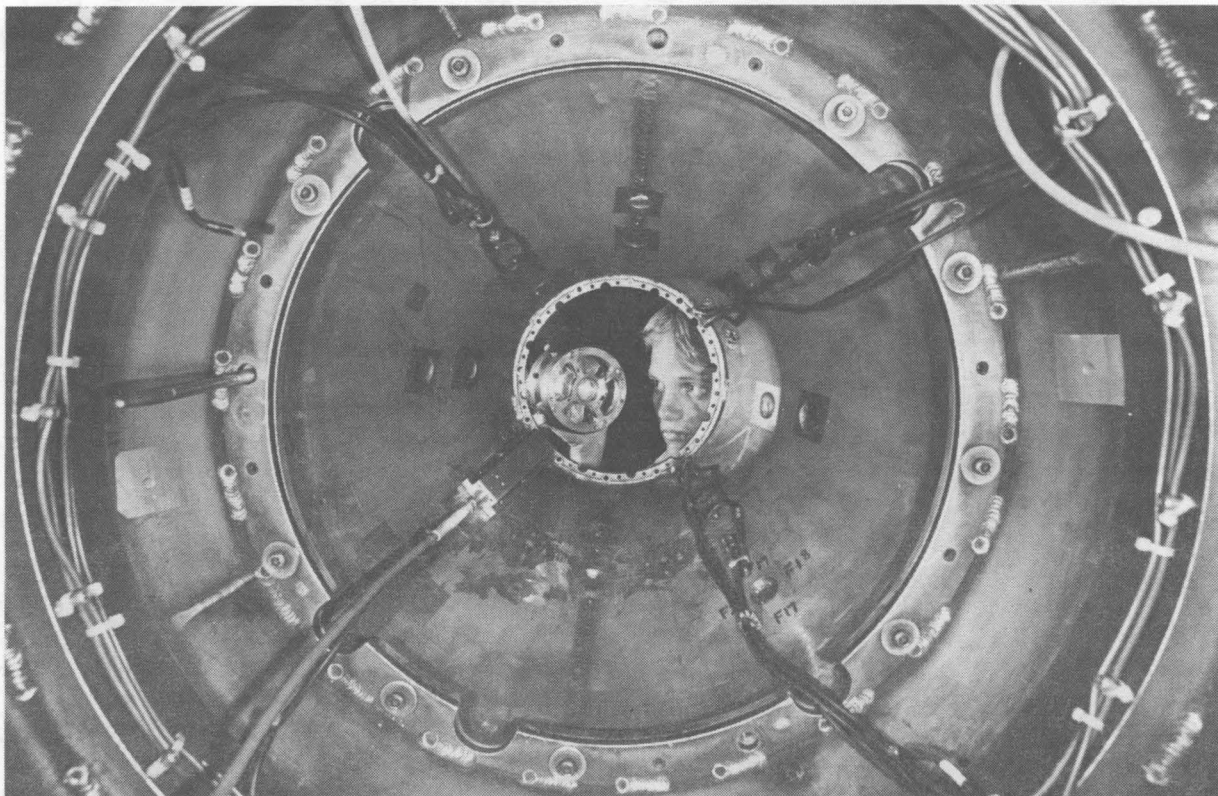
- Sandia achieved time-resolved measurements of plasma fluorescence that are the first unambiguous demonstration of an inversion in a plasma being excited by high-energy radiation. The measurements are a critical step toward

Quality

- A new plan streamlines evaluation and **certification of new semiconductor components** for use in low-volume production. Titled "The User Specific Parts Plan," it will first be applied to the W89 Joint Test Assembly Telemeter. The intent is to provide a system of selecting and validating the quality of electronic components that is flexible enough to allow the use of appropriate technology, allowing the engineer to achieve robust designs. The plan emphasizes quality of design rather than quality through testing, and focuses on producing systems that have wide, flexible design margins and less stringent component specifications. The goal of the program is to obtain the highest system confidence level possible within the constraints of available funding and schedule. (8400/2100)

- In keeping with Sandia's Quality and ES&H initiatives, the **Sandia Satellite Program Summary of Operational Procedures**, a policy and procedures manual originally issued in 1978, has been completely rewritten. The older manual was a 223-page collection of procedures and management memos. The new manual, titled "Sandia Satellite Program Summary of Operational Procedures (SAND 89-0397)," has 41 pages plus a 16-page index. It describes current policies and procedures related to payload design, fabrication, assembly, testing and inspection, systems integration with the host satellite, and quality assurance. Detailed procedures are referenced and are available from the Sandia film bank. The manual is now being updated to reflect new quality and ES&H guidelines. (9200)

- A new method of **quality assurance** based on improving the design and production process rather than testing for poor quality after the fact is proving to be more efficient and is being applied to the manufacture of semiconductor devices. Called Certification, Qualification, and Monitoring (CQM), the methodology evaluates



PEERING AT part of the diode, which is powered by the conical portion of the accelerator shown in the foreground, is Pat Lake (contractor). The accelerator is used to generate and focus an intense ion beam in the Particle Beam Fusion Accelerator II. (Photo by Randy Montoya, 3162)

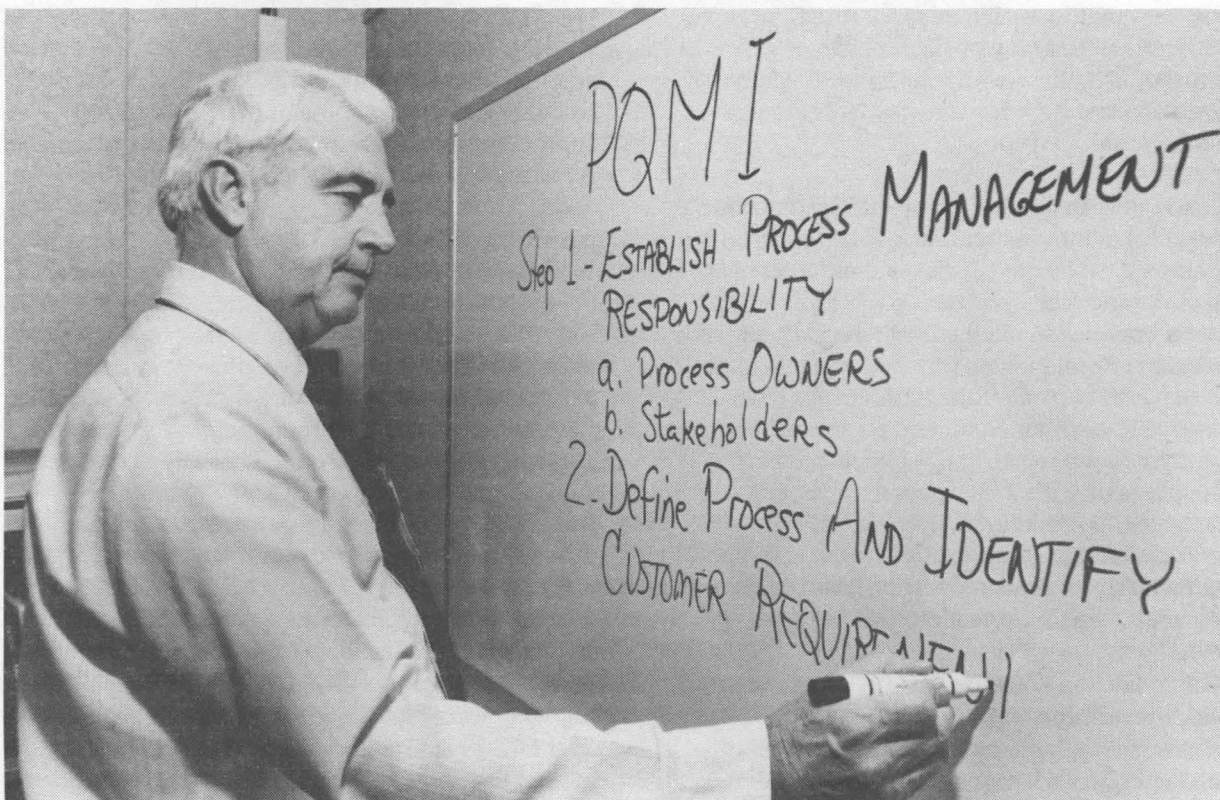
developing a **pulsed power-driven X-ray laser**. The inversions were created by the intense X-ray

emissions from a z-pinch implosion on Sandia's Saturn accelerator. (1200)

both the product and all of the technical and administrative activities that affect its quality. An objective, quantifiable rating system based on nationally recognized criteria determines if a process is well-defined, capable, and managed for continuous quality improvement. CQM is also being used as a self-assessment and improvement tool at Sandia and Allied Signal's Kansas City Division. (7300/2100/Allied Signal)

- Sandia is moving toward its goal of becoming a national leader in quality through the **Process Quality Management and**

Improvement program, also known as PQMI, a methodology first developed at AT&T and introduced this year at the Labs and DOE's Albuquerque Operations Office. Along with Quality Awareness training, PQMI makes up the core curriculum for quality education of employees. Training has been provided to senior management at DOE, the Sandia Management Council, the Sandia Quality Improvement Team, and about 100 employees each month. Sandia also facilitated the formation of process management teams during the training sessions to address continued needs for improvement. (7300)



TOM POTEAT, hired from Bell Labs to set up Sandia's Process Quality Management and Improvement program, reviews material to be covered in a training workshop. Tom is head of Sandia's Quality Support Div. 7311. He has trained instructors for internal quality programs at Sandia, DOE, and other DOE laboratories.

Laboratories Support

SANDIA EMPLOYEES — an estimated 4,000 — gathered on Hardin Field April 26, 1990, to hear talks by President Al Narath and four department managers on various aspects of Sandia's *Strategic Plan*.



- Several thousand employees attended **Vision Day** activities at Albuquerque and Livermore in April to kick off implementation of Sandia's *Strategic Plan*. The programs included employee speeches that illustrated the values of the plan. (3000/400/7800/8500)

- A new, low-cost program called **Brown Bagging with Brass** began this year in response to an employee survey that indicated employees wanted more direct contact with upper management. The series of informal luncheon meetings are hosted by members of Sandia's Management Council (such as vice presidents and executive vice presidents) who field questions from non-supervisory employees. More than 1,000 employees will have attended one of these sessions by early 1991. (3100/SMC)

- Significant progress has been made toward **removing obstacles to handicapped employees**. A special team that included one engineer and three physically handicapped employees identified many obstacles that needed correcting in Tech Area I, such as lack of ramps or improperly placed ramps, uneven pavement or walkways, inaccessible Mardix booths, narrow passageways, step-through doorways, and rough-surface walkways that look nice but are difficult to travel in a wheelchair. Many obstacles have been removed, and other modifications will be completed in the spring. Design standards are also being revised. (7800)

- A new **Image Management System (IMS)** stores design information, such as drawings and specifications, on optical disk and provides desktop electronic access via personal computer. The system provides an alternative to the distribution of design information on film and paper. Within the last year, two out of three film banks have closed, and distribution of hard copies of Engineering Releases and Change Orders has been stopped, saving 240,000 pieces of paper annually. The system now has more than 100,000 documents and nearly 300 users, is accessible through Sandia's Private Branch Exchange, and contains only unclassified information. (2800)

- Sandia implemented the first phase of a change in **administrative approval levels** in response to customer requests and in cooperation with the Project Management Implementation Committee. The result was a reduction in approval levels for acquisitions, personnel activities, accounting, and property transactions. (100)

- **WhiteStar**, a database that makes detailed searches for preferred parts, is now available to engineers at Sandia. The component database contains 8,058 active and passive electronic components plus mechanical fasteners identified by Sandia's Preferred Parts Oversight Board. It also includes engineer-requested parts, some of which have simulation model input files. This information helps ensure continued quality improvement, design manufacturability, and reliability of the parts supply used by weapon and space system designers. The project team is working with component engineers and data suppliers in other organizations to make the data accessible to engineers throughout Sandia. (2800/2100/2500/9300)

- Sandia's **TLC — Total Life Concept** — program was expanded last February to include more than 150 retirees. The program features cholesterol screenings, health risk appraisals, and seminars on Self Care, Physical Activity, Arthritis Management, and Heart Attack Prevention. The primary goal is to reduce health care costs for this segment of Sandia's population. TLC also joined the national campaign against drug and alcohol abuse with the addition of a new class, "Parenting Skills for Drug-Free Children." (3300/3500)

- A standards-based, internally secure **scientific computing network** was developed to integrate two newly acquired Cray Y-MP supercomputers (one in Livermore and one in Albuquerque) into a new computing environment. The network supports a seamless computing environment of Unix-based workstations and Unix-based supercomputers. Telecommunications capabilities were improved with a new phone switch in Area IV using AT&T's 5ESS state-of-the-art communications equipment. Building 823 was provided with an unclassified communication system for use outside of Tech Area I. This allowed access from Albuquerque to the Cray X-MP at Livermore for projects involving partnerships with industry and universities. (2900)

- **Upgraded electrical systems** will more adequately serve the increasing power demands in Tech Area I. Work is under way on a new 115-kilovolt electric transmission line, along with 115-kv/12.47-kv substations and a 12.47-kv underground distribution system. The systems will provide greater and more reliable power capacity than is currently available and will also be more flexible and cost-effective. (7800)

- Sandia's first **Strategic Plan** was developed and written in 1990 by members of the Sandia Management Council (SMC), working with representatives from throughout the Labs. During the process, planners reviewed the future environment affecting the Labs and identified customers and stakeholders, their needs, and Sandia's means of meeting those needs. During the process, they identified values of critical importance to the Labs and analyzed strengths and weaknesses, opportunities and threats. (100/400/3100/3500)

- Sandia has a **new payroll system** as part of the Human Resources Information System on the IBM mainframe. Conversion to the system was so smooth that most employees were unaware their paychecks had been produced by completely different hardware and software systems. (100)

- Managers and employees were acquainted with financial issues as they relate to Sandia's *Strategic Plan*, project management, and the changing corporate environment at a workshop called the "**Financial Information Exchange**." The workshop gave participants an in-depth opportunity to deal with financial issues of concern to them, such as financial reporting, support center activities, and the changing nature of Work For Others. More than 600 participants attended. The workshop also provided a basis for new initiatives, such as the Sandia Labs Financial Information System. (100)

- An **Upward Feedback Program** was put into place to support Sandia's new culture and to provide for more open communication with management. The program began with formation of a steering committee last February that included a cross section of directors, department managers, and division supervisors. In Phase I, each level of management from director through president received confidential, anonymous feedback from their subordinates one and two levels below them. After reviewing the feedback, recipients developed action plans to address areas of concern and met with subordinates. Internal consultants were nominated by vice presidents to assist with report formats, interpretation, and action plans. Phase II of the process will include department managers, division supervisors, and section supervisors as feedback recipients. (3500)

- A special panel is now responsible for overseeing **Sandia Laboratories Instructions (SLIs)**. The SLI Board works with employees to ensure that policies are responsive to the needs of line organizations. Functional organizations that have expertise and authority in a particular subject area are responsible for ensuring that their requirements are input into the SLI development process. (100)

- A new online database system called the **Access and Clearance System (A&CS)** offers immediate retrieval, addition, and updating of Sandia's **clearance, badge, and visit request** data. This computerization of access control and administrative support functions also has several other advantages, including daily automatic updates from internal and external sources, a personal computer-based backup system, and batch reporting capabilities. The system provides more accurate, complete, and timely information than previously possible and allows for future integration with other administrative computing systems. The major advantage of the new system is improved customer service in the form of quicker and more efficient processing of customer requests for access. (3400)

New System Is Up and Running**Voice Messaging Can Streamline Communication**

When a LAB NEWS "What Do You Think?" question asked for ideas on improving communication, a number of Sandians advocated some form of voice mail. Here's good news for those folks:

The Sandia Voice Messaging System (SVMS) is now in service for many Sandians, says Project Leader Gary Shepherd (2933). "It's far more than a glorified answering machine," he explains. "As you would expect, it can take messages while you're away from your office, but it can also take messages while you're on your phone. Or it can call you somewhere else and alert you that certain messages have been received."

Send Yourself a Reminder

SVMS can also broadcast a subscriber's message to personal lists of other subscribers, and even send messages at future dates and times to remind oneself or others of upcoming events or deadlines.

"Right now," says Gary, "400 customers are being added each week. About 1,400 should be

Who Can Subscribe?

At present, only people whose phone has an 845 prefix can subscribe to SVMS — those are the phones connected to KAFB's new electronic telephone switch. As more phone circuits are moved to the electronic switch, SVMS can accommodate more customers. Under current budgetary estimates, all Sandia phone circuits should be on the electronic switch within three years.

using the system by the end of February. People have already reported SVMS to be a powerful tool for improving communications, even after using it for only a few weeks. As just one instance, they can check their messages from any tone-dialing telephone. One cost-conscious subscriber has suggested that Sandia get an 800

number so that travelers can reach the SVMS while they're on the road. We're looking into that, and it promises to save Sandia thousands of dollars a year in phone bills."

The system is also letting some Sandians remove answering machines from their desks and thus fulfill a DOE security requirement.

Such a system isn't chosen as casually as one picks up an answering machine from a store shelf. "Our technical evaluation team consisted of Chris Morgan [2933], Lorraine McCutcheon [3151], and me," says Gary. "We examined many voice-processing products. We gained valuable experience from a pilot project that used DOE's Voicemail system. After looking long and hard to find the best system for Sandia's requirements, we believe we have a good match."

Helps When Needed

The system gives help when a caller needs it, but can be interrupted for quicker operation. For instance, if someone familiar with SVMS calls a subscriber and hears the beginning of that person's recorded "personal greeting," the caller can press the pound sign (#) and immediately leave a message. Callers who aren't familiar with the system can continue to listen and receive instructions.

A caller can review his or her message and change it if desired. It's also possible to mark a message "Urgent" so that the recipient will hear it first, or "Private" so that the subscriber can't forward it. (Features like these require a tone-dialing telephone.) One goal is to encourage callers to leave detailed messages, not just a name and phone number.

Although all callers can use some features of the system, subscribers will get the full benefits, says Gary. For instance, while reviewing messages, a customer can make the speech louder, softer, faster, or slower. He or she can also skip around in a message to review parts of it, or fast-forward through the message.

For subscribers, SVMS is like an electronic mail system that uses high-quality digitally recorded voice rather than written messages on paper or a computer screen. They can communicate with one another through SVMS mailboxes and eliminate the need for "telephone tag."

Features coming soon will be the notification of "messages waiting" to pagers and the addition

SVMS Training Scheduled

Sandians who have an 845 phone prefix should be invited to a voice-messaging training session by the end of February. Anyone who doesn't get an invitation can call the Voice Messaging System Administrator on 5-9445 to schedule a session.

of "bulletin boards" that callers can dial for information on Sandia-related topics. Future enhancements may include integration with electronic mail so that customers can have conventional electronic-mail messages read to them on the phone while they're on the road. The *Sandia Computing Newsletter* will have a Voice Messaging column, beginning in March, to pass on hints, tips, and notices of new SVMS functions.

"We believe the SVMS system can save Sandians a lot of time and callers a lot of frustration," says Gary. "Systems such as this can help Sandia remain competitive in an increasingly communications-oriented world." •

Take the Cheney Challenge

This is the fourth in a series of "helpful hint" columns as we strive to improve our ES&H performance and prepare for the DOE Tiger Team visit beginning in mid April.

TIGER TEAM TIPS

If you're wondering what to do to keep on top of ES&H activities in your area, try the "Cheney Challenge."

With the help of the ES&H Improvement and Compliance Program staff, Glen Cheney (3) has developed a four-step process to help employees understand ES&H requirements.

(1) Know what space and what work you are responsible for. Make sure that all your facilities have space owners assigned to them.

(2) Know what the hazards are for the space and work you are responsible for. This can be done by referring to Preliminary Hazards Assessments (PHAs), completed last year, and by walking through your space with an eye toward hazards. If you find a hazard not covered by adequate measures, take appropriate measures or actions prescribed by Sandia's ES&H Manual.

(3) Know what you are doing to manage hazards and reduce risk. If action plans for the hazards were not completed as a part of the PHA process, they should be completed now. An action plan can be something as simple as writing down what actions you will take and what further analysis of the problem you plan to perform.

(4) Document your ES&H activities. Write down what you are doing and share the information with others who may need to know it. Keep the information in a file and check it from time to time to see that you are doing what you said you would do.

Sandia managers will begin receiving Management Assurance Notebooks in the near future. These should be used to keep appropriate documentation, including records on employee training. A packet for employees and contractors is planned. This will provide the start for an individual ES&H file.

NEWS BRIEFS**Sandia, DOE to Commercialize Solar Power Technologies**

Seven solar energy companies will participate in a program to accelerate commercialization of photovoltaic technologies through Sandia and DOE. The companies recently signed partnership agreements with Sandia to develop cost-effective photovoltaic concentrating collector power systems.

Over a period of four years, DOE plans to allocate up to \$12 million to the Photovoltaic Concentrator Initiative, and each participating company will also contribute to development costs. The contracts are coordinated by Jay Chamberlin and Jim Gee (both 6224).

Sandia Shares World-Class Facilities with Industry

Sandia has announced a new cooperative program with US industry aimed at sharing Labs' facilities and techniques with US industry. The program, called the Microelectronics Quality/Reliability Center (MQRC) Affiliates Program, permits industry to use Sandia's unique test facilities and experience to improve the quality of microelectronics products and solve common problems in the industry.

Companies participating in the program will help sponsor research financially, while the Labs contributes the use of its test facilities and information. This saves companies the expense of building their own research facilities. Ted Dellin (2146) says the MQRC will not compete with private industry because the center will only allow research by outside companies when the technical capabilities are not available elsewhere.

Albuquerque Hosts Robotics Clean-Up Conference

Robots that can fight fires, perform military operations, clean up hazardous waste sites, and perform tasks in space will be the focus of a robotics conference to be held Feb. 24 through 28 in Albuquerque. The conference, the Fourth Topical Meeting on Robotics and Remote Systems, will explore the uses of robots in hazardous environments and for cleaning up hazardous waste sites. It is sponsored by the American Nuclear Society Remote Systems Technology Division. Participants are scheduled to tour the robotics facilities at Sandia and UNM as part of the conference.

Topics include: controls, mechanisms, and sensors; machine vision; telerobotic systems; mobile robots; hazardous material handling; nuclear reactor maintenance; computer programming and modeling; simulation; and environmental restoration of hazardous waste sites. More than 50 representatives from the national laboratories, educational institutions, and industries in the US, Canada, Germany, Japan, and France will make presentations.

"There's not a very good technology base for using robots in hazardous environments," says Pat Eicker (1410). "Recently, however, DOE has begun placing a huge emphasis on finding robotics techniques for hazardous waste cleanup because of the potential applications at sites such as Idaho, Hanford, and Savannah River." For more information, contact Pat on 6-6329.

What Do You Think?

Sandians Offer Ideas about Working with US Companies

This is the third in a series that features employee responses to questions posed by the LAB NEWS. The idea is to give Sandians an opportunity to suggest ways to make the Labs more efficient, more responsive, and perhaps a better place to work.

The current question, with a preface: "Agreements have been signed by AT&T, Sandia, and DOE that allow establishment of CRADAs (cooperative research and development agreements) with private industry. This enables Sandia to negotiate R&D agreements directly with domestic companies, in support of our technology transfer objectives. What specific actions do you think Sandia could take to attract/encourage appropriate US companies to work with us?"

The following responses were received. Only minor editing has been done:

Sandia should increase its involvement with university graduate student research and co-op programs. Sandia should have one day a month as an open-house day. Seminar speakers and visitors from industry could be invited to visit Sandia on these days. Sandia should encourage employees to visit colleagues in industry and provide seed money for potential collaboration programs. Finally, Sandia should develop a sabbatical exchange program with industry. Unless Sandia creates a more open environment, industry will continue to be reluctant to collaborate with us.

Arnold Howard (7415)

Sandia, Albuquerque presents a double barrier: Kirtland Air Force Base and the tech area fences. Let's put more buildings outside the tech areas when we can. A public-access corridor across Kirtland to Sandia would lower the physical and psychological barriers. For now, capitalize on whatever communication pathways we can, such as computer networks.

Name Withheld by Request

I don't know how many people Sandia has on the road advertising the Labs, but maybe we could form a small corps of well-spoken, technically savvy presenters, arm them with high-quality visuals (including videotapes), and have them knock on the doors of companies whose interests overlap our own.

Name Withheld by Request

Make Sandia a "kinder, gentler" company to do business with. CRADAs make it possible to partner with Sandia; let's make it easier to do busi-

ness. Establish an uncleared, on-site location where partners could "set up shop" for a short period to interact regularly with staff on joint projects. Establish a stylish, less constrained public relations capability to communicate how to partner with Sandia, the Labs' future technology interests, and how we plan to function as a supplier of technology. Sensitize staff to the benefits of participating in technology transfer and partnering through a documented rewards and recognition process.

Steve Goldstein (9020)

Have tech transfer trade fairs that are open to the public. Give public recognition to people who work successfully with private industry. Have "account executives" responsible for Sandia core capabilities and train them right. Invest in more information people who can publicize tech transfer stories and potential success stories in the trade and technical magazines. Work with state and university people who can act as "lead-getting" intermediaries in attracting visitors who could become collaborators. Work with the governor's science advisor to make technology initiatives an important part of the State Department of Economic Development charter.

Name Withheld by Request

Appoint someone in every technical directorate as the "industrial liaison specialist." Give them the primary responsibility for (1) identifying technologies in their directorates that are of potential interest to US companies and (2) identifying appropriate companies that may be interested in working with us to help develop these technologies and put them to good use. Give these specialists strong company support and some marketing (not a dirty word) training. Many Sandians aren't comfortable yet with the concept of marketing, but we need to use modern marketing techniques if we want to expand cooperative work with industry.

Name Withheld by Request

What Do You Think?

The Next Question: About Time & Money

"Little things mean a lot," according to an old song. That can certainly be true if a good little idea is shared with folks throughout the Labs. What is your best idea for saving Sandia money or time? (Answers can be on a personal, group, or Labs-wide level.)

Please limit responses to 75 words, concentrate on presenting constructive ideas, and include your name, organization, and phone number with your response. We print names and organization numbers with the response unless you request otherwise, but we'll call you personally to verify that you submitted it before we go to press. If you tell us you do not want your name associated with your response, we will not reveal your name to anyone, but we still need your name to verify that the response is from a Sandian.

Send responses to "Question," Division 3162, to arrive by noon on Wednesday, Feb. 13. If you prefer, responses can be faxed to 844-0645. Suggestions for future questions are appreciated.

A Unicycle Is More Than Half a Bicycle

Impractical Transportation, But Great Fun

Pedaling to work, Stan Fraley (9242) would normally be on a two-wheeler. But for fun he often opts for a one-wheeler.

The one-wheeler he's riding through a Tech Area gate in the photo is one of three different-sized unicycles he owns and rides as a hobby. Stan has ridden unicycles for 18 years. Now he enjoys accompanying his 5-year-old daughter, Cindy, who gave up training wheels on her two-wheeler six months ago, on rides in parks and on sidewalks.

"We go at the same speed," he says, "and if I had to, I could be off the unicycle and on my feet running to help her in a fraction of a second — much quicker than if I were on a bike." Stan says that his four older children all ride unicycles, and three are better than he.

Not Up to Circus Standards

As a result of a challenge by a friend, Stan learned not only to unicycle but also to juggle while doing it — an act that he says the neighborhood kids enjoy even though it's not up to circus standards.

He also says that anyone who can ride a bike can learn to unicycle, given willingness to practice and a helper with shoulders and arms to hang onto. He recalls falling only once that he didn't land on his feet; when the unicycle starts to go down, he says, it happens so quickly that the rider automatically lands feet-first, like a cat.

As a mode of transportation, though, the unicycle leaves something to be desired — its speed is



PAUSING for Felix Silva (3435) to inspect his badge, Stan Fraley (9242) encounters a challenge to his unicycling skill: It's tough to stop without putting the feet down. Stan did manage to hesitate long enough for a regulation-length badge check.

closer to walking than to biking, or even jogging. On the other hand, it's pretty safe. "I've taken more falls jogging than unicycling," says Stan. ●CS

Welcome

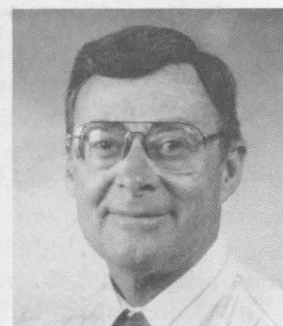
Albuquerque — Judith Borrowdale (21-1), Christine Chavez (21-1), John Ellis (7265), Dolores Gonzales (22-2), Valerie Griego (3530), Linda Hanson (21-1), Kenneth Harper (3212), Jana Lichlyter (3423-3), Virginia O'Neill (22-2), Stephen Schroeder (3532), Carolyn Smith (22-2); Other New Mexico — Douglas Drumheller (6252), Donna Elam (21-1), Hilary Thompson (22-2), Dionysius Vigil (3435).

Elsewhere: California — Douglas Loy (6211); Illinois — Thomas Corbet, Jr. (6344); Massachusetts — Debby Oscar (6461); Texas — William Bohnhoff (6412), Diana Dobias (21-1), Joan Gately (155), Steven Nichols (3734); Washington — Kathleen Alam (6612).

Recent Retirees



Robert Stromberg 412



Arthur Ahr 2800

30



feed back

Q: At the staff level, we seem to be inundated by initiatives — Change Management, Quality, ES&H — with no clear prioritization. My suggestion would be to incorporate all of these under a single VP (perhaps Glen Cheney) so there would be both the perception and the reality of a coordinated management plan. It would seem logical to refer to all of this as “Change Management,” since each program represents an effort to adapt or modify our present modus operandi.

A: I share your concern about the large number of initiatives being pursued at Sandia. I regret the heavy burden these activities have imposed on all employees. Were it not for a sense of great urgency driven by our increasingly demanding operating environment, I would have chosen a more leisurely pace. Nonetheless, your suggestion that more attention be paid to improved coordination and prioritization is a good one. In fact, we recently decided to concentrate all initiatives applicable to accomplishing our ES&H objectives. Bringing Sandia's ES&H performance in line with DOE expectations is a top priority. As you know, I have assigned Glen Cheney responsibility for directing the compliance effort. Since ES&H requirements affect every employee, the ES&H initiative is an excellent vehicle for translating our “Quality” and “Employee Empowerment” principles into practice. Toward that end, to the extent possible, we will focus our various quality and associated initiatives (such as “Project Management,” “Rewards and Recognition,” etc.) on ES&H improvements.

Meantime, Dan Hartley will continue to provide Labs-wide coordination of Sandia's change management activities. The need for significant improvements in internal (omnidirectional) communications is a particularly pressing challenge at

this time. Realizing Sandia's full potential will require far greater employee involvement and participation in managing the Labs' multifaceted activities than we have traditionally believed necessary. But this broadening of responsibility will improve performance only if our internal networks operate more efficiently than in the past.

As we look to the coming year, we all realize that much will be demanded of us by our customers. We also know we can achieve customer satisfaction by concentrating our efforts on that common purpose. I believe I can count on you.

Al Narath (1)

Q: I am a permanent, resident Sandia employee at the Nevada Test Site (NTS). My question concerns the new SLI 2008, “Smoke-Free Workplace.” Does this SLI apply to NTS? Some of the hard-core smokers have taken the position that since all the buildings at Mercury and the forward areas of NTS belong to the Defense Nuclear Agency, they are not Sandia property and do not fall under the provisions of SLI 2008. Many of these buildings are solely or 90-percent occupied by Sandia employees. I would appreciate a clarification. Some of the arguments are getting pretty heated, and not just with cigarette smoke.

A: The intent of Sandia's new “Smoke-Free Workplace” is to provide assurance that every Sandian may work in an environment free of tobacco smoke. The policy was structured to assist line organizations in decision-making regarding “Sandia facilities.” While I recognize that there may be some quibbling as to the “ownership” of facilities, in my view, the intent of this new policy is to offer all Sandians support regardless of their location. Accordingly, it is within the purview and

responsibility of line managers to assure that Sandia policies are equitably administered with respect to Sandia employees at NTS as well as other remote sites.

I have taken the liberty of routing a copy of your Feedback letter and my reply to Org. 9320 for consideration. I appreciate your interest and difficulty with the transition period associated with this particular issue.

Larry Clevenger, M.D. (3300)

Q: I always thought a person had to have basic skills, like being able to read and write, to be employed by Sandia. It's surprising how many people don't know what “reserved” means, as in “reserved parking.” During the past month, there have been four days when I arrived at work to find my medically ordered parking space occupied. Since security is having such difficulty keeping people out of reserved spaces, why can't these offenders have their vehicles towed to an impound lot? Perhaps after a few of them have to pay towing and storage fees to retrieve their vehicles, their reading ability would improve.

A: The Security Department enforces Sandia's Reserved Parking policy. On receiving a complaint, the Security Inspector confirms the violation and issues a parking citation. Security attempts to notify the violator, and if the vehicle is not removed within one hour, it is subject to tow. However, towing is a last resort and in most cases, the vehicle is moved within the hour. A letter is sent to the violator's supervisor, and corrective intervention by the line organization is required.

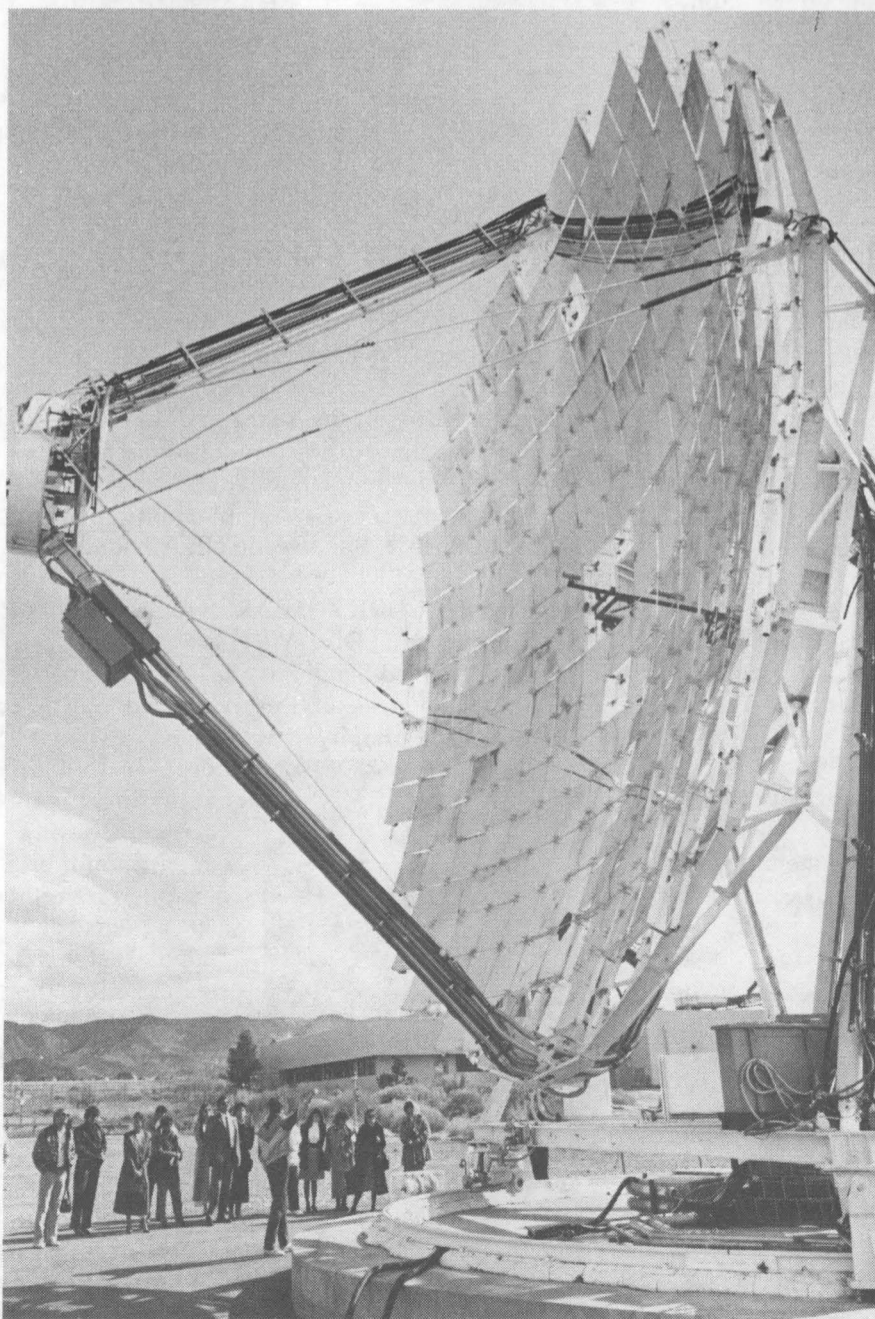
Jim Martin (3400)

Fun & Games

Running/Walking — Start the season with a 5K or 10K run, or a one-mile walk, in the third annual Presidents' Day Fun Run, Saturday, Feb. 16, at 10 a.m. at the Star Heights Recreation Center, 800 Polaris Blvd., Rio Rancho. Medals will be awarded for first- through third-place men and women in seven age categories. Registration fee is \$8 in advance, \$10 on race day. The first 300 entrants will get T-shirts. Advance registration is at the Rio Rancho Parks and Recreation Office or Gil's Runners World.

Skiing — Coronado Ski Club members, keep in mind that the club will subsidize ski lessons (\$10 per member, with a limit of \$20 per family membership). Send receipts to Ben Blackwell, 13732 Pruitt NE, 87112. CSC now has a discount ticket arrangement with Pajarito Ski Area (Los Alamos), in addition to Sandia Peak, Santa Fe, Taos, Purgatory, and Monarch. Discount tickets are available at the C-Club office. March will bring CSC Board elections — volunteers are needed and should contact Beth Gonzales on 266-2302.

Shooting — The Sandia Muzzle Loader Club offers a muzzle-loader safety course on Thursdays, Feb. 21 and 28 and March 7 and 14, at 7 p.m. at the Coronado Club. The course, which costs \$10, will include the history and safe handling of muzzle-loading rifles. To register, call the SERP office on 4-8486.



AT&T EMPLOYEES from facilities throughout Albuquerque get a look at Sandia's Solar Thermal Test Facility during a recent tour of facilities. The purpose of the tour was to give area AT&T employees an opportunity to learn what Sandia does. (Photo by Mark Poulsen, 3162)



Supervisory Appointments

DONALD LARRICHIO to Supervisor of Accelerated Procurement Systems Div. 3741.

Don joined Sandia's Purchasing Division in 1984 as a buyer. He transferred to the Purchasing Policy and Planning Division in 1985, developing purchasing instructions and conducting audits. He consulted buyers and chaired the Acquisition Review Committee, and was quality coordinator, liaison to DOE, and Freedom of Information Act representative. In 1987, Don joined Purchasing Div. 3726 as a buyer and transferred to Purchasing Div. 3712 in 1990.



DONALD LARRICHIO

He has a BA and an MA in public administration from UNM. He's also a member of the National Contract Management Association. Before joining the Labs, Don was Director of Purchasing and Materials Management at UNM. In 1977, he was appointed to the Governor's State Working Committee to write the New Mexico Model Procurement Code. He is a past chairman of the board of the New Mexico Minority Supplier Development Council.

Don enjoys tennis and aerobic exercises. He and his wife Sandy have two children and live in the NE Heights.

ALEXANDER HACHIGIAN to Supervisor of Weapon Training and Evaluation Div. II 7214.

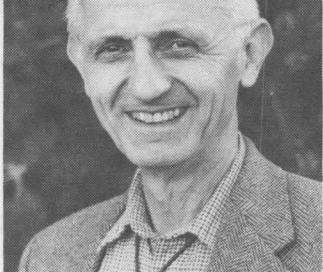
Al has been a member of the Military Liaison Department since joining the Labs in 1960. He provided weapon maintenance training and support services for fielded weapons in the Weapon Training Division. He was named a Distinguished Member of Technical Staff in 1989 "for his sustained technical contributions to the maintenance of a reliable stockpile of nuclear weapons through his excellence in weapon training and contributions to the solution of problems in the field."

He has a BS and MEd in mathematics education and an MS in electrical engineering, all from the University of Illinois. Before joining Sandia, he was an engineering trainee at the Sunbeam Corporation.

Al enjoys reading, backpacking, hiking, race walking, gardening, and biking. He and his wife Margaret have three sons and live in the NE Heights.

ROBERT McGRATH to Supervisor of Fusion Technology Div. 6428.

Bob joined Sandia in 1984 as a member of the Fusion Technology Division, where he researched plasma material interactions, tokamak edge plasma flow, and impurity transport. He was on temporary assignment in 1987 working on the TEXTOR tokamak at the Institute for Plasma Physics in Germany. In August 1990, he transferred



ALEXANDER HACHIGIAN

to the Laser and Plasma Processing Division and worked on discharge modeling of radio frequency discharges used for processing micro-electronic components.

He has a BS in engineering physics, an MS in physics, and an MA in mathematics from Pennsylvania State University, and a PhD in nuclear engineering from the University of Michigan. Before coming to the Labs, he was a member of the nuclear engineering faculty at Penn State and worked for Exxon Research and Engineering. He's a member of the American Physical Society and the American Vacuum Society.

Bob enjoys jogging and other sports. He and his wife Betsy Corwin have two children and live in Cedar Crest.

NANCY PRUETT to Supervisor of Recorded Information Management Div. 3145.

Nancy joined the Labs in 1981 as a technical information specialist in the Technical Library Reference Division. In 1986, she transferred to the Technical Library Systems Design Division, where she helped install a new version of DOBIS (the Library's online catalog). She was promoted to Supervisor of the Archives and Records Management Section in 1988, where she was responsible for the Sandia History Project, corporate archives, records management, and the records storage facility.

She has a BA in geology from Rice University, an MLS in library science from Texas Woman's University, and an MBA from Southern Methodist University. Before coming to Sandia, Nancy was head of the UCLA Geology/Geophysics Library.

She's a member of the American Library Association, the Association for Information and Image Management, the Association of Records Managers and Administrators, Beta Phi Mu (library science honorary society), the DOE Contractors Information and Image Management Association, the Geoscience Information Society, the Librarian's Association, the Society of American Archivists, the Special Libraries Association, and the Western Association of Map Libraries. She was named Boss of the Year for 1990 by the Rio Grande Chapter of the Association of Records Managers and Administrators.

Nancy enjoys cross-country skiing, reading, and wind surfing. She lives in NE Albuquerque.

CRAIG "CORKY" SEARLS to Supervisor of Systems Research Div. IV 9114.

Corky joined Sandia in 1981 as a member of the Strategic Petroleum Reserve Division, where he conducted geophysical studies; designed a borehole tool for evaluating casing corrosion, casing-cement bond, and cement strength; and coordinated the geophysical investigation for the Multiwell Experiment in Colorado. In 1987, he transferred to Systems Research Division IV, where he designed field experiments to characterize the physics involved in the propagation of light in the atmosphere and developed computer codes to model the physical phenomena.

He has a BS in physics and geology from the

University of Puget Sound and an MS and a PhD in geophysics from UCLA. He's a member of the Society of Exploration Geophysics and the American Geophysical Union.

Corky enjoys computers, cross-country ski racing, running, cycling, and backpacking. He lives in the NE Heights.

JAMES AUBERT to Supervisor of Target Fabrication Div. 1276.

Jim was a member of the Polymer Physical Properties Division from 1982, when he joined the Labs, until his recent promotion. While there, he conducted research on rheology, aqueous foams, microcellular polymer foams, and supercritical fluid extraction and cleaning.

He has a BS from the University of Michigan and an MS and PhD from the University of Minnesota, all in chemical engineering. He is a member of the American Chemical Society and the Materials Research Society. In 1989, he won the DOE nuclear weapons Award of Excellence for X-ray laser materials development.

Jim enjoys sports, coaching youth sports, camping, hiking, and building model planes and trains. He and his wife Wendy have two children and live in the NE Heights.

JOHN ANDERSEN to Supervisor of Phase I and Phase 2 Div. 5161.

John joined Sandia in 1955 as a member of the W25 Project Division, where he did mechanical engineering for design, development, and manufacture of the W25 warhead. He participated in full-scale atmospheric field test activities for Operation Teapot in Nevada in early 1955. In 1956, he left Sandia for two years' active duty in the US Army Corps of Engineers. After returning, he worked as a designer and project leader on numerous weapon, safeguards, nuclear energy, solar energy, and transportation projects.

From 1980 to 1981, John worked with the International Atomic Energy Agency in Vienna on nonproliferation safeguards and transportation. He was in Germany and Belgium in 1983, where he worked on personnel safeguards projects.

John was named Distinguished Member of the Technical Staff in 1983. In 1988, he received a DOE Award of Excellence for his work on concepts for rapid development of weapon capabilities.

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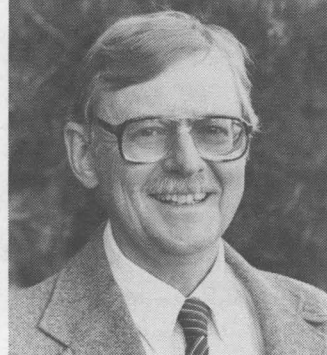
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•JW



Take Note

"Managing Contracts for Peak Performance" is the subject of a day-long seminar by the National Contract Management Association (NCMA) on Feb. 28 at the Holiday Inn Pyramid. NCMA is an organization of government and industry contracts professionals. The registration fee is \$125 for NCMA members and \$175 for non-members. To register, call Debra Niver on 828-5305. For information on NCMA membership, call Albuquerque chapter president Sue Cantrell (3714) on 6-9882.

The Cultural Diversity Colloquia Series (Div. 3511) presents a videotape of Asa Hilliard's "Ancient Africa's Contribution to Sci-

ence and Technology" on Thursday, Feb. 21, from 11:30 a.m. to 1 p.m. in the Technology Transfer Center. Hilliard is Professor of Urban Education at Georgia State University.

Retirement Seminar

Peter Arndt of New England Financial Group will present a seminar on planning for maximum retirement income, Tuesday, Feb. 12, in the Coronado Club Eldorado Room. The talk will review financial strategies to complement Sandia retirement income options and will highlight the survivor income insurance alternative.

Fun & Games

Bowling — SANDOE Bowling Association November Bowlers-of-the-month are: Scratch — Wayne Yoshimoto (7412), 698; Mary Alice Padilla (1500), 558; Handicap — Dick Radtke, 642, 723; Sally Frew (3524), 504, 651. Winners of the 5-Person No-Tap Tournament Jan. 19-20 were Jodi Case (3560), Paul Hatch (1832), Mark McAllaster (6322), Mel Mefford (3531), and Pat Mefford (6473), with a 3,476 team handicap series. Second went to Steve (9323) and Pearl Winters, Ella and Ernie Haralson, and Ken Wiltsie, with a 3,473 team handicap series. The next tournament is a 4-Game No-Tap/Scotch Doubles at Fiesta Lanes Feb. 23-24 (previously scheduled for Feb. 16-17.)

UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS • UNCLASSIFIED ADVERTISEMENTS

Deadline: Friday noon before week of publication unless changed by holiday. Mail to Div. 3162.

Ad Rules

1. Limit 20 words, including last name and home phone.
2. Include organization and full name with each ad submission.
3. Submit each ad in writing. No phone-ins.
4. Use 8 1/2 by 11-inch paper.
5. Use separate sheet for each ad category.
6. Type or print ads legibly; use only accepted abbreviations.
7. One ad per category per issue.
8. No more than two insertions of same "for sale" or "wanted" item.
9. No "For Rent" ads except for employees on temporary assignment.
10. No commercial ads.
11. For active and retired Sandians and DOE employees.
12. Housing listed for sale is available for occupancy without regard to race, creed, color, or national origin.

MISCELLANEOUS

GE MICROWAVE/ELECTRIC RANGE, one-piece unit, self-cleaning, automatic, oven timer, minute timer, clock, surface light, \$325. Villane, 275-3180.

PUPPIES, Australian Shepherd/Husky, grey and black on white w/reds, born 12/20/90, \$40. Babb, 865-6843.

AT&T PC6300 COMPUTER, 640K RAM, 2 floppy drives, green screen, \$650. Barr, 822-0671.

MOVING BOXES, peanuts and bubble wrap, \$35/all; Kenmore electric dryer, new heater coil, \$50. Tucker, 888-9786 evenings.

RACE CAR SET, HO Aurora (1963), w/ Tyco train set (1985), rare pieces. Weagley, 821-4263.

OCTA-GYM, multi-station exerciser, best offer; Craftsman 1/2-hp band-saw, \$50. Dunkin, 293-8801.

OLYMPUS OM2 CAMERA, 50mm lens, case, \$250; lenses: 100-200mm & 28-80mm for \$60, 300mm for \$40; T-32 flash, \$70. Nelson, 293-7283.

REFRIGERATOR, Ward's Admiral, frost-free, tan, 21.7 cu. ft., ice maker, 6 mos. old, textured doors, \$650 OBO. Reuss, 889-3641.

SIMMONS BABY CRIBS, 2; umbrella strollers, 2; twin stroller; high chairs, 2. Loudermilk, 299-4621.

POOL TABLE, half-inch slate, 8' x 4', \$400; electric dryer, \$100. Wiseley, 298-3195.

DISH SET, 9 settings (plates, cups, saucers), \$45. Tripp, 822-8580.

VACUUM CLEANER/ELECTRIC BROOM, Sears First Mate II, lightweight, one speed, \$25. Adelman, 292-0563.

ARTWORK: Peter Hurd print, "Late Call," signed, \$200; Art Menchego print, "Mother Earth's Children," signed, numbered, \$150. Coningham, 293-9563.

POSTUREPEDIC FULL-SIZE BED, \$400; Precor rower, \$100; assorted small tables, \$15-35; wedding dress, petticoat size 6, \$30. Morrow, 823-9468.

CANON CAMCORDER VM E1, w/hard case and extras, \$300. Matthews, 821-3015.

R.C. GORMAN PAINTING, original, framed, approx. 36" x 32", call for details. Baca, 296-6985 evenings.

WHEELS, 4, 5-hole, 14-inch, \$50; bike rack, for hatchback, \$20; black leather jacket, size 39, \$175; ski rack, \$25. Harding, 291-9449.

DESK, two drawers, 30" x 48" x 26", grey formica top, \$55; couch, two-seater, curved arms/back, new, \$80. Beck, 294-4591.

JAYCO 30-FOOT TRAILER, 1988, w/air, awning, microwave oven, TV antenna, booster, spare tire, & extra battery. Benson, 268-9727.

APPLE II PLUS COMPUTER, 64K RAM, Super Serial card, game paddles, \$100; ImageWriter printer, \$80; both, \$170. Greulich, 281-5424.

GOLF CLUB IRON SET, PGA Cameron, R.H. regular-shaft, non-cavity, used 5 times, \$175. Stang, 256-7793.

PUPPIES, AKC-registered, Lhasa-Apso, do not shed, 2 males, 1 female, parents on premises, 17 weeks old, shots, housebroken, \$300/ea. Kuehn, 281-2727.

BRASS BED, queen-size, complete headboard & footboard frame, w/box spring & mattress, \$250. Russell, 823-2441.

CASSETTE DECK, \$50. Robinson, 293-7231.

WHEELCHAIR BATTERY CHARGER; tire chains; tubular fireplace grate; wood basket; engineering drawing/drafting instruments; Ruger Bearcat 22-cal. revolver. Chavez, 275-0490.

TWIN BOX SPRING, mattress, & frame; Sealy Posture Flex, \$100. Schmitt, 291-0878.

EPSON LQ500 PRINTER, 24-pin, tractor/single sheet, font cartridge slot, two internal font sets, \$200. Henderson, 884-8309.

FURNITURE: Danish tables, couch, chairs, nightstand, foot stool; beige rug & pad, 12' x 18', cleaned, will sell separately. Kerschion, 281-1671.

SOFA & LOVESEAT, Ethan Allen, beige background, multi-print, \$400. Schneeberger, 298-5955.

MILITARY HISTORY BOOKS, hard cover, \$5/ea.; paperbacks, 75¢/ea. Estes, 865-5525.

GARAGE SALE: Feb. 9, 9 a.m. - 4 p.m., 1609 Chelwood Blvd. NE; clothes, furniture, auto items, sports equipment, household items. Leeman, 299-9149.

LITTON K-LATHE; Paragon A-99B kiln; Texsaw 200 diamond-blade band-saw. Lewandowski, 265-2122.

BUNK BEDS, w/mattresses, side rails, ladder, \$150. Carroll, 292-5436.

SLIDE-IN CAMPER, Mitchell Fishing Hut, w/ice box, furnace, stove, \$750 w/o jacks, \$825 w/jacks. Eisenberger, 877-7041.

RATTAN LOVESEAT w/ blue & white calico seat, back cushions, \$25; matching round rattan foot stool, \$10. Cook, 888-2928.

CHEVROLET TRANSMISSION, 4-spd., fits up to '75 Chev. 1/2-ton, \$100. Blea, 881-4900.

CANON AE-1 CAMERA, w/ 28mm, 50mm, & 300mm zoom lenses, Sunpac flash, tripod, carrying case, \$300. Torres, 865-3984.

IMPORTED CHINESE RUG, ivory w/peach, blue, green, & yellow, 6' x 8', new, \$200. Locher, 266-2021.

KING-SIZE WATERBED, 6-drawer pedestal, \$150. Rael, 345-2084.

FEMALE FISCHER LOVEBIRDS, 2, \$30/ea.; handmade wooden or wire cage available. Chinn, 296-5172.

FULL-SIZE MATTRESS, w/ box spring, metal frame; blue upholstered chair w/fruitwood legs and trim. Flanigan, 299-0049.

CERAMIX HEATER, in original carton, high-efficiency ceramic PTC heating element, compact, powerful, sells for \$100 new, \$50 OBO. Weston, 255-1196.

WHIRLPOOL GAS DRYER, \$100. Orand, 275-2255.

WEIGHT BENCH, \$45; student violin, \$95; Nelco sewing machine, w/cabinet. Biffle, 293-7043.

REFRIGERATOR, Kenmore, top freezer, 20 cu. ft., ice maker, almond, textured doors, 4 yrs. old, \$450 firm. Olsen, 294-2333.

WOODEN WORKBENCH, 32" x 12', \$25. Mozley, 884-3453.

SPANISH-STYLE BIRDCAGES, small \$100, large \$290; Sears H/D washer/dryer, gold, \$225/pr.; \$125/ea. Pullen, 291-0666.

KING-SIZE WATERBED, w/bookcase & mirrored headboard, dark wood, new heater, padded rails, \$175. Santana, 294-0536.

KAYPRO PC, dual 5-1/4" floppy drives, software, no manuals, \$100. Lambert, 281-5798.

SECTIONAL SOFA, 3-piece, w/oak trim: 1-arm love seat, 1-arm sleeper sofa, corner table, \$450 OBO. McConnell, 296-0376.

PC MONITOR, Amdek, color, for IBM or Apple; CGA board for IBM, \$100. Lagasse, 293-0385.

CHARTER MEMBERSHIP, Pendaries Park at Rociada, NM, clubhouse, cottages, RV pads, golf, tennis, recreational activities, selling at discount. Nicovich, 299-1430.

QUEEN-SIZE SOFA SLEEPER, matching chair, tan corduroy, oak trim, \$550; glass-topped wood coffee table, \$75. Elbring, 247-4565.

SKIS, Pre 1200, 200cm, Tyrolia 380, \$90. Davis, 296-6022.

TELEVISIONS, less than perfect, make offer. Moss, 298-2643.

AQUARIUMS, dog beds, cages, toys, 2,000 books, household goods, clothes, western hats, boots, snow tires, table, scrap lumber. Davis, 294-4614.

'88 TERRY RESORT TRAVEL TRAILER, fully self-contained, AC, awning. Provoost, 265-1932 after 5 p.m.

TRANSPORTATION

'76 DATSUN 710 2L, runs but needs work, 115K miles, \$200 OBO. Dye, 897-0304.

'83 TOYOTA CRESSIDA, 4-dr., AT, power windows/locks/mirrors/antenna, AM/FM cassette w/equalizer, sunroof, digital dash, T/computer, \$5,500. Fries, 292-4193.

'82 BMW 733i, 4-dr., sunroof, AT, AC, leather interior, \$7,000. Coningham, 293-9563.

CENTURION SUPER ELITE BICYCLE, 10-spd., 27-in., \$410. Aragon, 294-9957.

'89 FORD TEMPO GL, transmission warranty, 4-dr., AM/FM cassette, cruise, tinted windows, tilt, \$7,900 negotiable. Cartwright, 836-6957.

'80 FORD BRONCO, FWD, 6-cyl., 4-spd., 67K miles, \$3,700; '79 VW Rabbit, diesel, 40-mpg, 65K miles, \$700. Rountree, 296-7268.

'85 MAZDA RX7-GSL, red, AT, AC, sunroof, 44K miles, \$5,500. Crooks, 293-7008.

'65 CHEV. CAPRICE MALIBU, 4-dr., 50K+ actual miles, PS, PB, AT, AC, see at 3616 Stardust Dr. NE, \$1,200 OBO. Neil, 884-4461.

'80 CHEV. CITATION, 74K miles, 2-dr., beige, AC, AT, 22mpg, passed emissions, new parts/receipts, \$1,400. Schofield, 292-7220.

'81 JEEP CJ7 LAREDO, hard top w/ sun roof, bikini top, see on Wyoming near B-52. McConahy, 884-5071.

BICYCLE, Specialized Allez Epic, 1989, carbon fiber frame, Shimano 600 component group, \$850. Kovacic, 256-9867.

REPOS: '90 Plymouth Laser RS, 22K miles; '81 Ford Van, Econoline 150, 71K miles; '89 Nissan Maxima, 33K miles. Sandia Labs FCU, we reserve the right to refuse all bids, 293-0500.

'78 VOLVO 244DL, \$2,850. Portman, 266-7648.

'63 FORD THUNDERBIRD LANDAU, 390 eng., AT, PS, PB, PW, vinyl roof. Hole, 873-0652.

'75 PLYMOUTH VALIANT CUSTOM, 57K miles, AT, AC, PS, PB, 4-dr., slant 6, new tires, belts & hoses, \$975. Rezac, 292-2669.

'87 LeBARON COUPE, 4-cyl., steel grey, power, trip computer, 16K miles and/or 45 months remaining on transferable warranty, \$5,995. Andrews, 299-1319.

'62 STUDEBAKER LARK, 4-dr., new paint, PS, 6K miles on rebuilt engine, \$1,200. Blea, 881-4900.

'88 FORD AEROSTAR XLT, dual air, digital dash, trip computer, cruise control, captain seats, more, 41K miles, must sell, \$9,000 OBO. Torres, 865-3984.

MOUNTAIN BIKE, Specialized Rock Hopper Comp, 21-spd., original owner, \$400 OBO or trade for dirt motorcycle. Pryor, 294-6980.

'77 BRONCO, 83K miles, 4-WD, V-8, AT, AM/FM tape, red & white, 32-in. tires, white spoke wheels, \$3,950. Muirhead, 281-2925.

'87 JEEP CHEROKEE LAREDO, 58K miles, 5-spd., 4-cyl., Command-Trac, AC, cruise, PW, PL, \$9,900. Adelman, 898-0335.

'80 HONDA CB650 MOTORCYCLE, \$500 OBO. Roeske, 255-6188.

'86 NISSAN 300ZX TURBO, 5-spd., burgundy, T-top, ground effects, 55K miles, new tires, maintenance records, \$9,999. Morris, 294-1048.

'88 CORVETTE CONVERTIBLE, 22K miles, blue/black, '90 Chev. Dually Silverado, 4x4; both \$1,500 below retail, warranty, options. Davis, 296-6022.

REAL ESTATE

3-BDR. HOME, 2 baths, 2 car garage, 1,950 sq. ft., Cherry Hills NE, owner finance \$120,000, buyer finance negotiable. Ater, 822-9697.

CORRALES LAND, .92 acre, residential area, irrigated, \$59,500. Miller, 268-5992.

4-BDR. HOME, 3 full baths, 2,585 sq. ft., 3-car garage, wet bar, fireplace, appraised at \$170,000, sell for \$144,900. Vandewart, 298-4741.

MOUNTAIN BUILDING SITES, views, approx. 3 acre lots in Tijeras Canyon, 13 miles to Sandia. Souder, 281-3121.

3-BDR. HOME, SE area, Territorial style, w/covered porches, enclosed patio, brick floors, skylights, built-ins, overlooks golf course, \$125,900. Chapman, 255-7634.

3-BDR. MOBILE HOME, 1-1/2 baths, 1,440 sq. ft., large storage area, Vineyard Mobile Home Park. Rael, 345-2084.

3-BDR. HOME, 1 bath, garage, walled yard, covered patio, hardwood floors (carpet covered), landscaped, Parkland Hills. Kent, 256-1221.

WANTED

HOUSEMATE, female, non-smoker, share NE Heights house, 2-car garage, \$250/mo. + 1/2 utilities. Schafer, 296-8645, leave message.

MAXIMA OR CRESSIDA, 4-dr. w/in-line 6-cyl. engine & rear-wheel drive only, must be in excellent condition. Boyd, 298-4712.

PRACTICE SPACE for drug-free band, 3 to 4 nights a week, reasonable monthly rate. Rhoden, 293-5301.

HOUSEMATE, in Cedar Crest, non-smoker, male or female, 1,900 sq. ft., deck, 1/2 acre, own bedroom & bathroom. Pott, 291-0261.

STAIR STEPPER, exercycle, or similar equipment. Sharp, 243-1498.

VOLUNTEERS: University Hospital needs Information Desk volunteers at its new Ambulatory Care Building opening this spring. Broyles, 344-3872.

CROSS-COUNTRY SKI BINDING, Secura Fix, size medium. Souder, 281-3121.

DIRT BIKE, old or in need of repair, cheap, cash or trade mountain bike for it. Pryor, 294-6980.

VT100 TERMINAL and/or RACAL Modem, needed for school work. Craig, 246-8464.

LOST AND FOUND

LOST: Woman's Citizens gold watch, contact Mary Ann Monia (1000), Bldg. 806, Rm. 270, reward amount to be discussed. 6-9519 days, 842-6045 evenings.

FOUND: Country Gentleman Tray/Ler cap, grey, found at 3700 Quality Awareness Seminar (Marriott courtyard). Sikora, 4-1163.

LOST: Man's Seiko watch, gold plated band, black face, lost in Bldg. 823, sentimental value, \$25 reward, no questions. Graf, 266-7885.

SHARE-A-RIDE

CARPOOL WANTED, Rio Grande & Griegos area to Area I (Bldg. 802), 8 a.m. to 4:30 p.m. Krantz, 345-4075.

Coronado Club Activities

Weary Workers Go West For Western Night

WAY OUT WEST (west of Wyoming Blvd., that is), the Isleta Poor Boys are playing your favorite country and western songs. Tonight, Feb. 8, from 7 to 11 p.m., the C-Club invites you to Western night. Menu items include: filet mignon or fried shrimp (two-for-one price \$14.95), poached halibut, prime rib (both \$7.95), and chicken teriyaki (\$6.95). Reservations recommended (265-6791).

KIDS' BINGO IS BACK, Sunday, Feb. 10, starting at 1 p.m.. What Santa didn't bring, the C-Club will, such as Nintendo's "Game Boy" and other great prizes. The cost is \$2.50 per player. A low-cost buffet will also be served starting at noon.

TREAT YOUR SWEET to the sweetheart swing, Friday, Feb. 15, with music by the Orlie Saavedra Big Band from 8 to 11 p.m. Dinner is served from 6 to 9, a special five-course meal that includes salad or soup du jour, filet mignon or Coquilles St. Jaques Mornay, baked potato or rice pilaf and vegetables, roll and butter, valentine

cake, a flower for your sweetheart, and a half-liter of house wine per couple (\$26 per couple). Make reservations early.

EAT, DRINK, AND BE MERRY at next Sunday's champagne brunch and arts & crafts fair, Feb. 17, from 10 a.m. to 1 p.m. The family feast includes eggs, omelets, potatoes, bacon, baron of beef, turkey, ham, vegetables, salad, green chile stew, deserts, and juices (\$5.95 for adults, \$1 for children 4 to 12 years old, and free for kids under 4). Kids get a C-Club frisbee free with brunch. Reserve a table early.

TERRIFIC TAOS will be the subject of February's Ski Club meeting, with speaker Chris Stagg of Taos Ski Valley. The social starts, as always, at 7 p.m., and the meeting starts at 7:30. Spaces are still open for two of this season's ski trips: Breckenridge, Feb. 23 through 27 (contact Brian Behling on 898-7657), and Wolf Creek, March 1 through 3 (contact Archie Stannish on 821-0914).

Take Note

The 11th annual Cystic Fibrosis Foundation's fundraising "Pit Climb" is Saturday, Feb. 16, from 9 a.m. to 1 p.m. Participants run laps around or stair flights up the UNM "Pit." UNM Lobo Coach Dave Bliss will host the event. To join Sandia's corporate entry, Sandians and contractors can call Tim Wheeler (6321) on 4-9554.

Each year the Southwest Institute, an instructional program for the Center for Southwest Research at UNM, concentrates on a different geographic area of the Southwest. The Institute has organized a three-week lecture series for 1991 and four separate six-day field sessions, entitled "Gateway Plains and the Santa Fe Trail," that will tie together the natural and cultural elements of the Gateway Plains of northeastern New Mexico and southeastern Colorado. The first field session is April 29-May 4; the registration deadline is April 12. A brochure that provides complete information about the program, lecture topics, and the field route and stops can be obtained by calling the Institute on 277-2828.

Events Calendar

Events Calendar items are gathered from various sources. Readers should confirm times and dates of interest whenever possible.

Feb. 8-20 — Exhibit, "First Encounters: Spanish Exploration in the Caribbean and the United States, 1492-1570," 9 a.m.-5 p.m. Tues.-Sun. (closed Mondays), Albuquerque Museum, 243-7255.

Feb. 8-March 17 — Exhibit, "Robert M. Ellis: A Painter's Space," by New Mexico artist and professor emeritus of UNM's Art and History Dept.; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues. & Wed. evenings, 1-4 p.m. Sun.; UNM Art Museum, 277-4001.

Feb. 8-March 17 — Exhibit, "Interrogating the Essence," joint exhibition featuring recent work of Stuart Arends and Allan Graham; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues. & Wed. evenings, 1-4 p.m. Sun.; UNM Art Museum, 277-4001.

Feb. 8-April 14 — Exhibit, "Wolves and Humans," from the Science Museum of Minnesota, provides comprehensive picture of the social, biological, and mythological relationships between wolves and humans; 9 a.m.-5 p.m., New Mexico Museum of Natural History, 841-8837.

Feb. 8-16 — "Charley's Aunt," comedy by Brandon Thomas; 8 p.m. Mon.-Sat., 2 p.m. Sun.; Albuquerque Little Theatre, 242-4750.

Feb. 8 — Mardi Gras Dance, costume dance presented by the Albuquerque Parks and Recreation Dept.; 8 p.m.-midnight, Albuquerque Convention Center, 768-3490.

Feb. 8-9 — Pops Concert Four, New Mexico Symphony Orchestra, featuring Emmy Lou Harris; 8:15 p.m., Popejoy Hall, 842-8565 or 842-8566.

Feb. 9 — "An Evening of Chinese Music," traditional Chinese songs performed by the Albuquerque Chinese Chorus; 8:15 p.m., Keller Hall, 296-8067 or 828-3680.

Feb. 9 — New Mexico Jazz Workshop Guest Artist Series: Hugh Masakela, South African trumpeter, composer, and bandleader; 8 p.m., KiMo Theater (419 Central NW), 255-9798.

Feb. 9 — "The Fetish Carvers of Zuni" Grand Opening, exhibit presented by the Zuni Pueblo and the Maxwell Museum, 135 fetishes carved from a variety of materials, accompanied by photos of the artists; 10 a.m.-4 p.m., Maxwell Museum of Anthropology (UNM Campus).

Feb. 10 — Dessert Tasting, finest pastry chefs in Albuquerque; 2-5 p.m., Albuquerque Garden Club (10120 Lomas NE), 884-7502.

Feb. 10 — "Arts in the KiMo," variety of entertainment; 2-4 p.m., KiMo Theater (5th & Central NW), 768-3490.

Feb. 10 — Chamber Concert presented by the Albuquerque Philharmonic Orchestra, directed by Elliot Higgins; St. Andrews Presbyterian Church (5301 Ponderosa Ave. NE).

Feb. 13-24 — "Othello," by William Shakespeare, presented by the New Mexico Repertory Theater; 8 p.m. nightly, 2 p.m. matinees Sat. & Sun., KiMo Theater (5th & Central NE), 243-4500.

Feb. 14 — Swedish Folk Fiddle Music, by Jonny Soling and Kalle Amlof, renowned fiddlers from Malung, Sweden; 8:15 p.m., Keller Hall, 296-8067 or 828-3680.

Feb. 15-16 — Classical Concert Number Six, New Mexico Symphony Orchestra, featuring Gary Hoffman, cello, and the Baroque Dancers with Wendy Hilton directing; 8:15 p.m., Popejoy Hall, 842-8565 or 842-8566.

Feb. 15-17 — Shrine Circus, Tingley Coliseum (NM State Fairgrounds), 265-1791.

Feb. 17 — "Baroque," Chamber Orchestra of Albuquerque presents the music of Bach, Telemann, Handel, and Vivaldi with David Oberg conducting; 3 p.m., St. John's United Methodist Church (2626 Arizona NE), 881-0844.

Feb. 17 — "Celebration," The Company singers present a 20th Anniversary Concert; 4 p.m., First United Methodist Church (4th & Lead SW), 243-5646.

Feb. 17 — Wind Ensemble Concert, presented by the UNM Music Dept.; 3 p.m., Popejoy Hall, 277-4402.

Feb. 19 — "Mimbres - More Than an Art Style," People of the Southwest Lecture, Dr. Stephen Lekson, curator of archeology at the Santa Fe Museum of Indian Arts and Culture presents the Mimbres culture; 7:30 p.m., Maxwell Museum of Anthropology (UNM Campus).

Feb. 21 — African Folk Tales, presented by Linda Piper; 1:30 p.m., South Broadway Cultural Center (1025 Broadway SE), 848-1320.

Congratulations

To Mary and Ron (1543) McIntosh, a daughter, Brittany Dawn, Jan. 20.

To Marianne Walck (6231) and Eric Chael (9244), a son, Andrew Alan Chael, Jan. 21.



MASKED MAN ROBERT SILVA (7813), pipe fitter apprentice, seals a pipe joint as part of his hands-on training at Sandia. During their five-year apprenticeships, trainees spend 10 percent of their time in formal classroom instruction and the other 90 percent doing hands-on work under an experienced journeyman. Apprentice programs at Sandia, one in Facilities Org. 7800 and three in Materials Process Engineering and Fabrication Org. 7400, have provided training in the major trades since 1958. (Photo by Randy Montoya, 3162)