

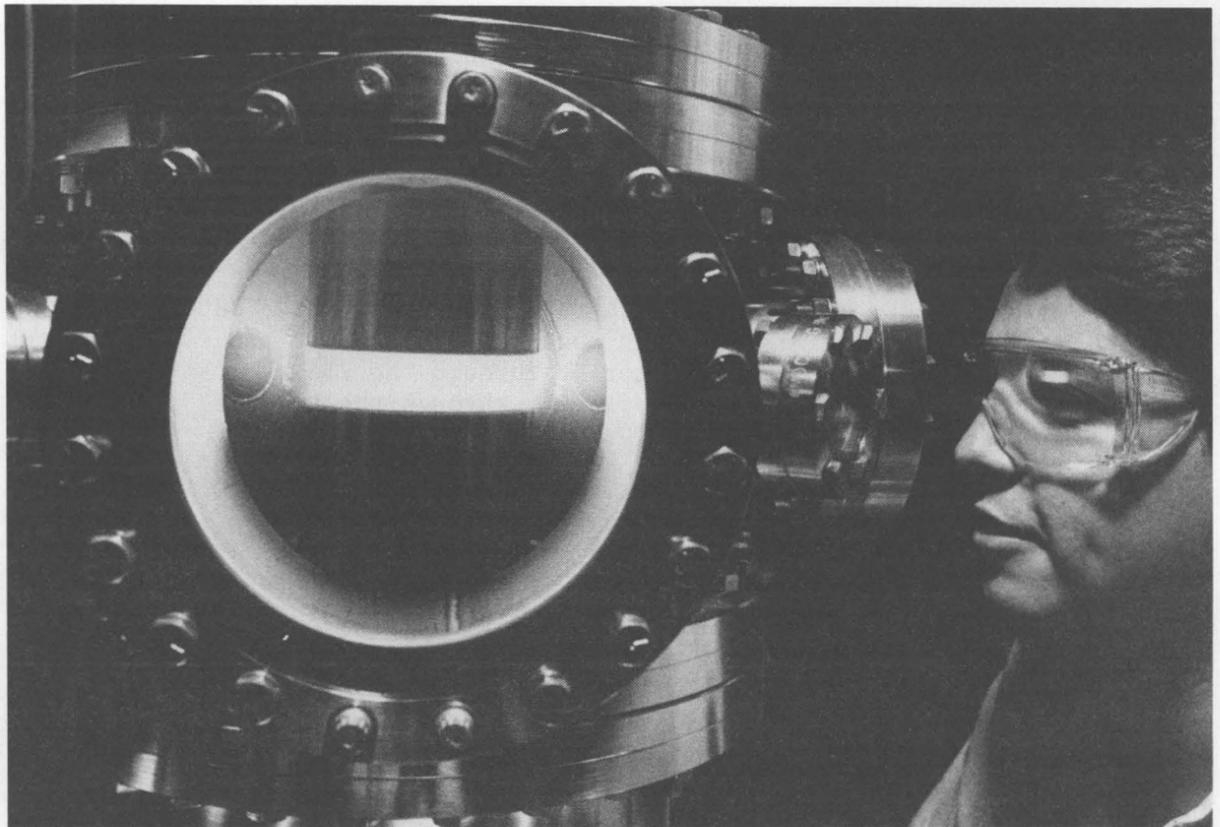
New Plasma Reactor Benefits US Microelectronics Industry

Imagine getting to work this morning if all computer chips suddenly stopped working: electronic alarm clocks wouldn't buzz, most coffee makers wouldn't brew, and modern automobiles wouldn't start. Offices would be graveyards of computers, copiers, calculators, phones, faxes . . .

"The list is endless," says Jim Gerardo (1120). "Without microelectronics, many modern weapons and a lot of everyday devices simply wouldn't work."

But the US is losing ground in the lucrative but competitive microelectronics industry it once dominated. That's why Jim and a small group of Sandians — Ken Greenberg (1128), Paul Miller (1126), and Phil Hargis (1128) — jumped at the chance three years ago to initiate and lead a national effort to develop a standard plasma research reactor, called the GEC RF (radio-frequency) Reference Cell, which is already benefiting US research in plasma etching, an essential step in microelectronics manufacturing. (GEC stands for Gaseous Electronics Conference, where the concept was first discussed in 1988.) The new Reference Cell provides the basis for communication among plasma researchers and helps standardize results made on different reactors.

"The \$50 billion-a-year microelectronics industry is the heart of the largest market in the world — electronics — which employs 2.5 million Americans," says Jim. "By coordinating projects
(Continued on Page Four)



PEERING through "portholes" in the GEC RF (radio frequency) Reference Cell is Ben Aragon (contractor). Sandia initiated and led a national effort to develop the standard plasma research reactor, which is already benefiting US research in plasma etching, an essential step in modern microelectronics manufacturing. (GEC stands for Gaseous Electronics Conference, where the Reference Cell concept was first discussed in 1988.)
(Photo by Randy Montoya, 3162)



LAB NEWS

VOL. 43, NO. 18 SANDIA NATIONAL LABORATORIES SEPTEMBER 6, 1991

Focus on Alta Mira

Your ECP Contributions Help Sandians And Others Meet Special Needs

The 1991 Employee Contribution Plan (ECP) campaign will be held the week of Oct. 7. This is the first of several related articles. The ECP campaign is a part of the area United Way campaign.

Your ECP dollars are sometimes needed "close to home." Sandians Tonya (151) and Don (112) Wichhart got help from a United Way agency after their twin sons were born Oct. 16, 1990. Alta Mira, a United Way agency, was there to help when they learned their son Geoffrey had mild cerebral palsy

and vision problems. Geoffrey and his twin brother, Derek, were born three months prematurely. Derek is developing normally.

An occupational therapist from Presbyterian Hospital told Tonya and Don about Alta Mira Specialized Family Services. Betty Yoches, an Alta Mira case manager, went to their home and helped coordinate the services Geoffrey needs.

The Wichharts participate in Alta Mira's Early Intervention Program, which provides educational
(Continued on Page Five)

ALTA MIRA case manager Betty Yoches (left) and Tonya Wichhart (151) hold twins Derek and Geoffrey Wichhart as they discuss the Alta Mira services needed by Geoffrey (right), who has cerebral palsy. Tonya and her husband Don (112) are among several Sandians and many others in the Albuquerque area who are helped by Sandians' contributions.



Kids' View

Children Invited to Enter Drawing Contest

Do you have youngsters in your family who like to draw? Would they be willing to enter their masterpieces in a contest?

If so, invite them to participate in Kids' View, a drawing contest that Sandia is sponsoring in conjunction with Family Day Oct. 19. Three winners will each receive a \$100 US Savings Bond. The drawings will be displayed in a special Family Day exhibit.

The theme of the drawing is what kind of work the child's parent or grandparent does at Sandia. Contest rules are simple. The sketch must be in black felt-tip pen on white paper, up to 17 inches by 22 inches in size. A short description, written or narrated by the child, of the work done by the Sandian should accompany the entry or be included as part of the drawing. Any child 13 or younger who is related to a Sandia employee may enter.

The deadline for mailing entries is Sept. 27. All entries will be judged by a panel of three members of the Family Day Planning Committee. The LAB NEWS reserves the right to publish and crop the drawings and to edit the work descriptions.

Please mail entries (with a piece of cardboard backing, if needed) and the entry form on page five to: Kids' View, Div. 3162. Or drop off the entry at the LAB NEWS office in Bldg. 814. Questions may be directed to Joe Laval (3163) on 4-6531.

•LD

FAMILY DAY

N · I · N · E · T · Y O · N · E

This & That

I Didn't Need to Hear This - I recently heard a radio newscaster report that newspaper editor has again made the list of the most stressful jobs. To top it off, I heard it while driving to work on a Monday morning!

* * *

Hey Sandians. Can You Spare an Evening? - Most schools are in full gear again, and they're looking for volunteer tutors to help their students. Several have already contacted Sandia's Volunteers In Action (VIA) Coordinator Al Stotts (3163), asking for tutors in specific subjects. As usual, science and math tutors are in demand, but others are also needed (see VIA article on page seven). Al says about 150 Albuquerque Sandians did volunteer tutoring through the VIA program last year and that others volunteered directly through the schools, probably bringing the total to more than 200.

I sure wish volunteer tutors had been available back when I was struggling through algebra and physics. Who knows? With proper training, I might have found honest work and become rich and famous instead of merely famous.

* * *

A Naval Salute - We couldn't squeeze it in with our *USS Iowa* coverage on pages 8 and 9, but an acknowledgment in the original report thanked the Navy for its cooperation with Sandia's investigators. Dick Schwoebel (300), who headed the Sandia team, says our work couldn't have been done without the close cooperation of the Navy personnel, particularly those at the Naval Ordnance Station, Indian Head, Md.; Naval Weapons Support Center, Crane, Ind.; and the Naval Surface Warfare Center, Dahlgren, Va.

* * *

Got Your Calendar Marked? - Just a short reminder that Saturday, Oct. 19, is Family Day at Sandia, Albuquerque. Sandians, retirees, and their families will have an opportunity to visit different areas of the Labs from 9 a.m. to 4 p.m. and see some interesting exhibits and fascinating demonstrations. We'll have details in upcoming issues. In the meantime, anyone who has questions may call Joe Laval (3163), chairman of the planning committee, on 844-6531.

* * *

Is There a Vaccine? - As contrived as it sounds, "scrumptox" (see Aug. 23 "This & That" column) is reported to be a real word - a name for a disease associated with rugby, spread by close contact during the game. And "tinnock" is not the front pleat of a kilt, but a bird, says Assistant Editor Charles Shirley.

I've received several responses to my call for phony - but real-sounding - high-tech words and definitions (or real words, with phony definitions), but I'm gonna hold 'em until next time to see if more come in. Send candidate words and definitions to "This & That," Div. 3162; anonymous contributions are welcome, but add your name if you want.

* * *

Aging and Painting - You don't hear it said often anymore, but one way of saying you plan a big night out is to say you're gonna "go out and paint the town red." My boss, who (let's face it) is starting to get some serious miles on his personal odometer, reportedly still does that but now has to wait several weeks before applying the second coat. •LP

Bob Peurifoy Commended by Secretary Watkins

Following is the text of a letter that Secretary of Energy James Watkins recently sent to retired Sandia VP Bob Peurifoy, commending him for his many years of contributions to the nation's nuclear weapon program. Bob retired this year after 39 years of Sandia service.

Dear Mr. Peurifoy:

I extend the best wishes of the Department of Energy to you upon your retirement from Sandia National Laboratories. The Department recognizes and applauds the outstanding service you have given to our national security programs. I note with much admiration that you were a prime participant for the Department in every major nuclear weapons safety study that occurred during your career. The most notable efforts include the "Transfer Study," "The Starbird Study," the President's Blue Ribbon Task Group on Nuclear Weapons Program Management, and the House Armed Services Committee "Drell Panel Study."

Over the years, your candor in raising critical safety issues was always valued. Your strong advocacy for improving the safety of deployed weapons resulted in the concept of a Stockpile Improvement Program. Your promotion of maximum commonality, with minimum variance between warheads for various service cruise missiles, resulted in significant cost savings. The first integrated arming, fusing, and firing system, developed under your personal direction for the Navy, set the standards by which all reentry systems are currently gauged.

Thank you for your outstanding contributions to engineering excellence at Sandia. Your career has indeed been marked with exceptional service to the United States and its national security.

Sincerely,

James D. Watkins
Admiral, US Navy (Retired)



BOB PEURIFOY

LAB NEWS

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feed back

Q: I believe Sandians overwhelmingly support an awards program to recognize the special achievements of employees who have worked in technical fields over long periods of time, yet who are not in line for rewards through managerial promotions. However, many eyebrows were raised by the last batch of DMTS awards, which are exclusively reserved for those staff members ranked by management as being in the top 10 percent of the salary ranks. The achievements of many of these DMTS honorees were not very different from the contributions made on a regular basis by most Sandians. In addition, several DMTS award recipients were promoted to supervisory posts soon afterward, yet did not have long-term achievements in technical specialties.

Doesn't this exacerbate the situation by which management heaps rewards on its chosen top 10 percent, while telling the other 90 percent that their work is relatively unimportant? If we are to achieve true teamwork at Sandia, wouldn't the money from the DMTS program be better used in narrowing the gap in salaries between the top and

middle ranks of Sandians?

A: In general, the DMTS program has been considered very successful over the years. It is intended to recognize technical excellence, and DMTSs are considered to be seasoned experts in their specialties. The work of the DMTS requires a high level of initiative and judgment.

The work of all Sandians is important. Teamwork has always been an important aspect of getting the job done. It is one of the five values in Sandia's Strategic Plan. As team players, we should all work to achieve our organization or project goals while also contributing our own ideas and efforts in a way that fosters mutual respect.

A Process Management Team (PMT), with input from a Quality Action Team (QAT) comprising a cross-section of MTSs and management, is currently reviewing the selection process for DMTSs. We trust this will improve the process and respond to your concerns. [The Oct. 4 LAB NEWS will discuss a revised DMTS selection procedure that allows MTSs to nominate their colleagues.]

Ralph Bonner (3500)

From Historically Black Colleges and Universities

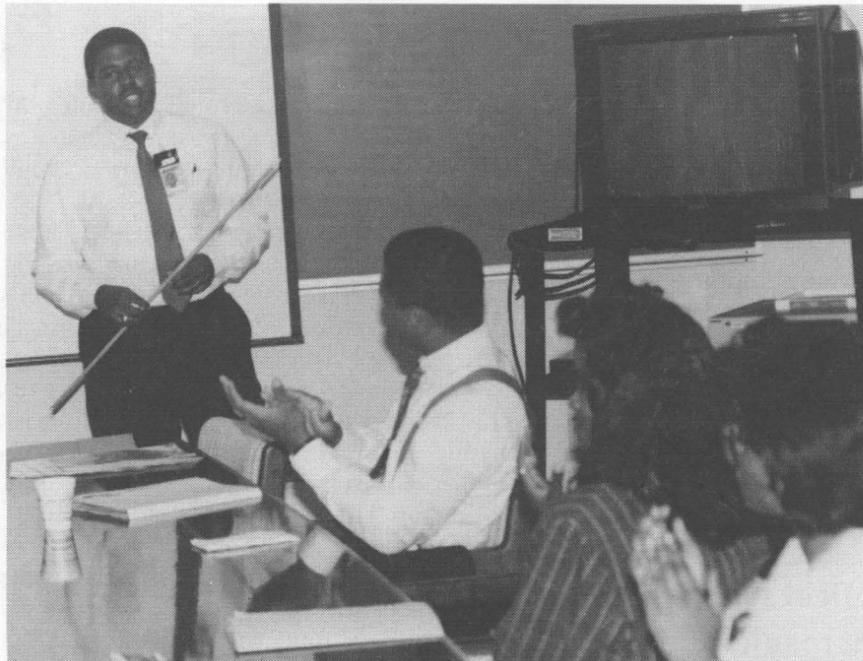
Students Gain Confidence, Work Experience at Sandia

Five students from Historically Black Colleges and Universities (HBCU) have just completed their summer work. Sandia, Livermore has considerably expanded its participation in a federally sponsored science and engineering program for HBCU students since 1983, when the Labs formed a collaboration with Jackson [Mississippi] State University.

Nationally, the initiative began under President Reagan in 1981. When President Bush renewed the program in 1989, he said, "For more than a hundred years, the Historically Black Colleges and Universities have been a special part of our heritage. At a time when many schools barred their doors to Black Americans, these colleges afforded the best and often the only opportunity for a higher education. Today . . . most of those barriers have been brought down by the law, and yet, Historically Black Colleges and Universities still represent a vital component of American higher education, enriching a great tradition of educational choice and diversity in this country."

At a presentation with this year's five HBCU students, Sandia's special programs coordinator Denise Robinson (8526) reviewed the history of Sandia's involvement since the agreement with Jackson State. "Our purpose and that of the national initiative," Denise said, "is to expose faculty and students of Black schools to advanced technology in the Laboratories, to transfer the advanced technology developed here to the colleges, and to provide a more highly trained work force from which Sandia and DOE may draw."

Sandia, Livermore's effort has included summer faculty and students working on-site, equipment loans, lectures by Sandians at colleges around the country, and a cooperative research and development agreement. Denise explains, "We had our first summer faculty member in 1985, coming



BRYAN MCDONALD, of Prairie View A&M in Texas, reports on his summer Sandia experience working on the ion microtomography project in Div. 8347.

from Southern University in Baton Rouge, to work in the Combustion Applications Division [8362]. That same summer, we hosted two students from Jackson State working in computer science and chemistry. In 1989, we started a cooperative research effort with Morgan State University, spearheaded by Bill Ormond [8543]. This year, Ralph James [8342] began another such effort with Fisk University."

Seeing the 'Practical Side' of R&D

Bryan McDonald, from Prairie View A&M in Texas, spent this summer working with Art Pontau and Dan Morse (both 8347) on the ion microtomography project. The junior in electrical engineering helped build the second-generation beam line. He says, "This experience was really beneficial to me. I learned a lot about the research they do, and the technology out here is massive. In school, you get your knowledge from books, but here you get to see the practical side of using it every day in R&D."

Linda Parker, another Prairie View electrical engineering major, worked with Roger Tilley (5313) doing computer modeling of worst-case

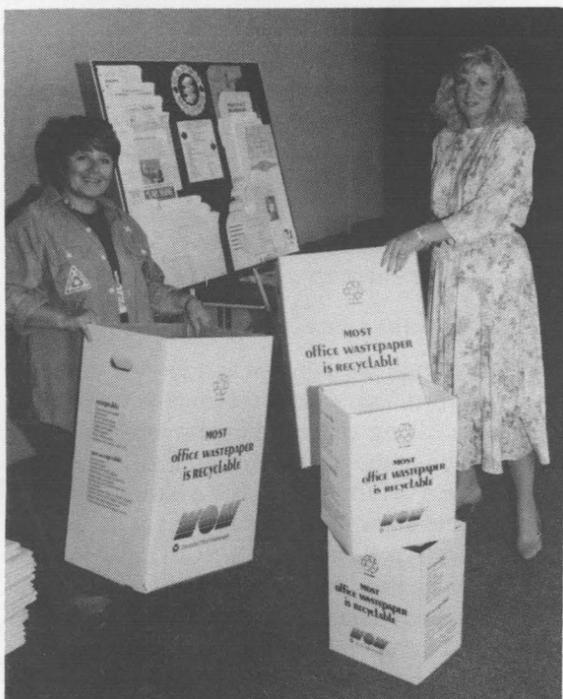
loads for the power supply on the SRAM II missile. "It has been an experience- and knowledge-building summer for me, and the staff here has been very helpful," Linda says. She plans to attend graduate school next year.

Allavine Bell from Southern University at Baton Rouge has been working with Wen Hsu (8347) creating a data base for studies of erosion on tiles exposed to plasma, as part of magnetic fusion research on the 3D-3 Tokamak at General Atomics, San Diego. An electrical engineering major, she plans to attend graduate school. "I was undecided about going for my master's, but my experience at Sandia this summer has helped me make the decision," she says. "I've learned a lot more about computers here, and I found the assignment productive, not just busywork."

The other two participants were Carlos Gethers, who worked in Mechanics of Materials Div. 8243, and Dominique David, who was in Advanced Materials Research Div. 8342. They agree that their exposure to a national lab and its resources has helped them feel more confident in their career goals and the directions they are taking toward science and engineering. •BLS



SANDIA LIVERMORE NEWS



LIVERMORE EMPLOYEES are now recycling white and computer paper through a pilot program in nine buildings and at the Credit Union. The paper recycling campaign was spearheaded by a grassroots committee of concerned employees formed by Cindy English (left, 8522). The recycling boxes were distributed at a kickoff coordinated by the Waste Minimization and Pollution Prevention Site Coordinator, Alice Johnson-Duarte (8542). Expansion of the program to all site buildings is being planned. Cindy and Alice are seen here assembling recycling boxes.

Taking Advantage of Differences

Seminar Explores Diversity in Workplace

An intense one-day seminar on cultural diversity held for Livermore Sandians a few weeks ago encompassed ethnic, cultural, and gender differences and involved Sandians at all levels.

Linda Houston (8526), Equal Employment Opportunity/Affirmative Action coordinator, says that diversity should be seen as a positive force by offering non-traditional viewpoints that lead to innovative solutions. "One objective of the seminar," says Linda, "was to provide an opportunity for learning how to interact effectively in diverse groups, and to do so in the complex organizational issues facing Sandia."

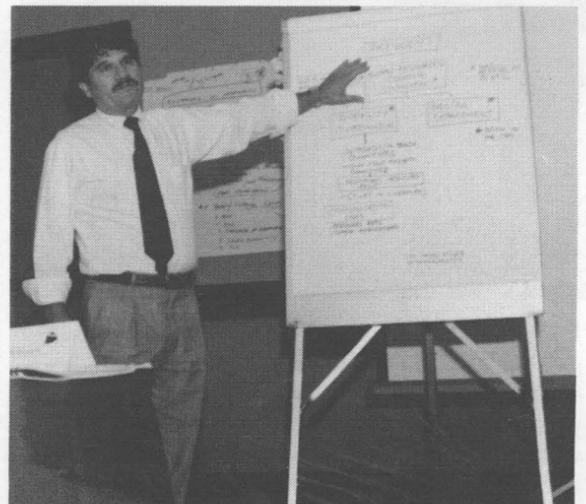
Linda adds, "We need to develop a corporate vision for dealing with ethnic, gender, and cultural diversity in the work force. This vision needs to be strongly supported by top management. The seminar was specifically designed to bring together all levels of management and staff for an in-depth discussion of diversity."

Groups Worked on Specifics

After an introductory session, participants divided into five working groups to explore specific strategies for achieving and valuing diversity in the work force. The groups worked on topics such as Vision, Strategy, and Objectives; Communicating Diversity; Support Systems for Diversity; Diver-

sity at All Levels; and Organizational Infrastructure and Roles. Later, the afternoon session focused on strategies and plans.

One of the 10 Albuquerque participants, Dan Hartley (VP-6000), says, "This was a great opportunity for those of us on the Sandia Management Council to hear directly from an ethnically
(Continued on Page Five)



MIKE ROBLES (8520) presents findings from his working group on Organizational Infrastructure and Roles.

(Continued from Page One)

Plasma Reactor

such as the development of the Reference Cell, the Labs can bring important benefits to microelectronics manufacturers."

Complex Ionized Gases

Plasmas — gaseous mixtures of ions and electrons — can be created when a neutral gas such as hydrogen is exposed to high voltage. As electrons in the gas become accelerated, they collide with atoms or molecules in the gas. Some molecules are ripped apart, some atoms or molecules are ionized in a cascading "electron avalanche," and others are excited to higher energy states. The resulting plasma is chemically complex.

As some of the excited atoms and molecules relax back into their lower energy states, light is emitted, giving the plasma its characteristic glow.

"Even seemingly identical reactors often produce different results."

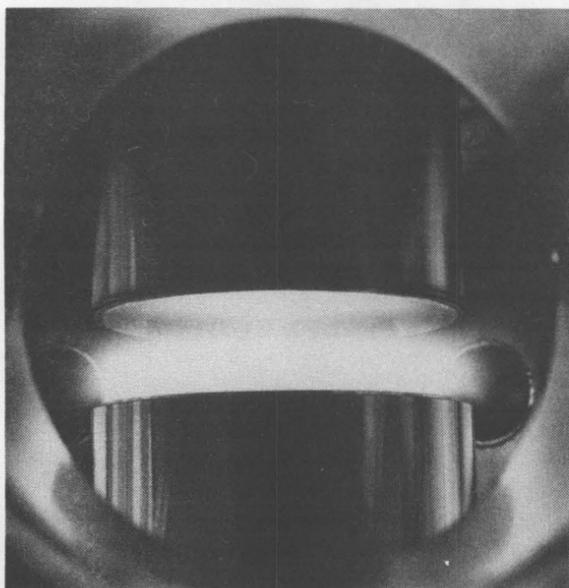
"This is the principle behind the fluorescent light bulb," says Ken. "As excited mercury atoms relax into lower energy states in a fluorescent tube, light energy is given off."

Plasmas used to make microelectronic circuits are created inside a chamber, called a reactor. A typical commercial reactor contains two parallel plate electrodes between which a silicon wafer is mounted. As low-pressure gas is injected into the chamber, a radio-frequency voltage is applied to the electrodes, forming a plasma.

Subtle Differences

In microelectronics manufacturing, plasmas are used to etch patterns onto semiconductor wafers (see "Why Wet's Out — Plasma Etching Packs More In"). Because of the chemical complexity of plasmas, however, these etching processes were developed without a basic understanding of the underlying physics that governs plasma behavior.

"In the past, etching recipes were often developed simply by turning the knobs until the desired etch was achieved," says Paul. "Today, more stringent etching demands are showing the weaknesses of this strategy and the need for a better understanding of plasma etching processes." Typically, it takes several years and close to \$5 million to work out the bugs in a \$1.5 million leading-edge reactor,



PLASMA'S characteristic glow is a result of excited gas atoms and molecules relaxing back into lower energy states. In microelectronics manufacturing, plasmas are used to etch patterns onto silicon wafers mounted between two parallel plate electrodes (seen here). As low-pressure gas is injected into the reactor, a radio-frequency voltage is applied to the electrodes, forming a gaseous mixture of ions and electrons.

Tiny Transistors

Why Wet's Out — Plasma Etching Packs More In

Twenty years ago, a typical computer chip contained only several thousand transistors. Now, a typical chip contains as many as 10 million transistors per square centimeter.

To achieve such transistor densities, manufacturers rely on plasma etching, a critical process in the manufacture of microelectronics, says Jim Gerardo (1120). Plasma etching is more effective than traditional wet chemical etching methods because plasmas require less wafer handling during production and leave less residue. More importantly, plasmas can be used to etch straight into material without drifting, or "undercutting."

In the manufacturing of silicon-based chips, for example, a silicon wafer is overlaid with a thin layer of silicon dioxide (SiO₂). Next, a patterned overlay is formed from a photoresist material (material sensitive to light), which leaves certain areas of the SiO₂ exposed. During plasma etching, only these exposed areas can be etched away.

Etching takes place inside a plasma reactor,

which contains two parallel plate electrodes attached to a high-voltage radio-frequency generator. A silicon wafer is mounted on one of the electrodes.

As low-pressure gas is injected into the system and ionized by the high-frequency voltage, the resulting chemically reactive plasma etches exposed portions of the SiO₂ — leaving a pattern of tiny holes and trenches.

The resulting pattern is used to form, or "grow," transistors by adding materials to the exposed silicon wafer. In chip fabrication, a chip may be etched 20 or more times to create a variety of different circuit elements, including tiny connecting wires, transistors, and capacitors.

At Sandia, plasma etching is an essential process in the fabrication of prototype and research microelectronic and optoelectronic devices, says Jim. It also is a key research focus of Sandia's Semiconductor Equipment and Technology Center (SETEC), funded by SEMATECH, a consortium of leading semiconductor manufacturers.

a costly prospect, adds Solid State Sciences 1100 Director Fred Vook.

A major obstacle to understanding plasmas used in microelectronics manufacturing was the difficulty in comparing results obtained in different reactors. Subtle differences among reactors and hundreds of variables — gas flow rate, chamber

"Some skeptics argued that a standard reactor would inhibit research innovation or that it wouldn't work."

size and shape, gas pressure, electrode spacing, voltage level, and even variations introduced by the power source — affect etching performance. "Even seemingly identical reactor systems often behave differently and produce different results," Phil says.

As a result, researchers in the plasma processing field worked independently of each other, using their own reactors. "Comparing results with other researchers was meaningless," he says. "We needed to agree on a standard point of reference so that everyone in the field could discuss and compare their findings."

Some Skeptical at First

At the 1987 Gaseous Electronics Conference, attendees discussed the possibility of calibrating plasma research reactors to an established set of standards. Most agreed, however, that calibration wasn't feasible given the number of variables.

The Sandians soon developed another solution. Plasma researchers might establish an inexpensive standard research reactor, called the GEC RF Reference Cell, that could be manufactured and used by plasma labs all over the world. Then they could introduce a uniform set of diagnostics for the cell that would validate plasma conditions and make research comparisons more meaningful.

At the 1988 GEC, the Sandians presented the Reference Cell concept at a workshop and volunteered to coordinate the cell's development. "Some skeptics argued that a standard reactor would inhibit research innovation or that it wouldn't work," says Paul.

But Labs-hosted follow-up meetings confirmed that support was adequate to move ahead. Attendees agreed that the Reference Cell should be technologically relevant to the US microelectronics industry, should accommodate a variety of ex-

periments, should be relatively inexpensive, and should be theoretically tractable.

Moving Ahead

Phil and Jack Simchock (2858) blueprinted the system, and SEMATECH (a consortium of leading semiconductor manufacturers) sponsored its development. Sandia soon transferred the blueprints to equipment manufacturers; the GEC RF Reference Cell is now a catalog item (costing approximately \$10,000, not including peripheral equipment such as a vacuum system).

So far, 15 Reference Cells are being operated in labs in the US, and 15 other laboratories have expressed interest in buying one. Phil says the system gives researchers a common starting point and a basis for interlaboratory comparisons because it allows researchers in the field to compare actual data taken on different reactors, leaving less room for interpretation.

The result: several joint papers have been published recently in the technical journals, one with 20 authors from throughout the plasma research community. "Now scientists and engineers can communicate more meaningfully among themselves," says Phil. "The Reference Cell is a tool to conduct better science."

Sandia Leadership the Key

"Developing the concept and design was a nationwide effort," says Jim. "It brought everyone together discussing and agreeing on what was best for the future of the plasma processing field."

"It's also demonstrated that a national lab can coordinate a major research project for the benefit of US industry," he adds. "The R&D laboratories have an obligation to take a leadership role and help US industry, especially where national competitiveness is concerned."

Many people from Sandia and the plasma research community helped develop the Reference Cell. John Torczynski (1513) performed fluid dynamics modeling on the cell, Brad Smith (2131) provided measurements from commercial plasma reactors, Joe Verdeyen of the University of Illinois helped develop electrical characterization methods, and Harold Anderson (UNM) helped set up one of the first Reference Cells. The Sandians also worked with researchers at Michigan State University, Wright Patterson Air Force Base, the National Institute of Standards and Technology, and AT&T at Murray Hill, N.J.

●JG

(Continued from Page One)

ECP and Alta Mira

and therapeutic services for children from birth to three years of age. Family members are helped through various support-group programs. "What's special about the early intervention program," says Betty, "is that we collaborate with the family."

Betty worked with Tonya and Don to develop an individual family service plan that describes ways to meet the child's and family's needs. Parents are given information and recommendations so they can make informed decisions regarding appropriate services for their child.

Alta Mira also has a program that provides respite care for individuals with special needs. So the primary caregiver can have some time off, care may be provided in the home of a trained provider or in the home of a disabled person.

Al Stotts (3163) is president of Alta Mira's board of directors. "During the years I have been a volunteer member on the Alta Mira board, I have come to appreciate the challenges faced by families with children or adults who have developmental disabilities," he says. "I have seen families work with Alta Mira's staff to face those challenges with determination and love. Alta Mira is an effective and important agency in our community." ●JC

(Continued from Page Three)

Diversity Seminar

mixed group, to learn about their attitudes and opinions on issues that we need to resolve. It provided excellent input and helped us understand some of the things we need to deal with."

Dan adds, "I felt that people at all levels spoke out and had valid things to say. The seminar gave me new insights on how we ought to be structuring our corporate view of managing diversity."

Another participant, Mike Robles, Manager of Management Services and Human Resources Dept. 8520, says, "To me, the diversity issue really fits into the model that Al Narath presented in his Labs-wide vision meetings on how Sandia culture needs to change. Diversity goes hand in hand with quality and empowerment. Diversity is how you address people issues to ensure that you have a competitive and productive work force, taking advantage of their skills and talents at all levels while respecting everyone's differences." ●BLS

Kids' View Entry Form

(See story on page one)

Child: _____	Age: _____	<input type="checkbox"/> Written by child <input type="checkbox"/> Narrated by child (check one)
Parent's/Grandparent's name: _____	Parent's/Grandparent's org. no.: _____	
Child's description of work done at Sandia: _____		

Oversees Strategic Planning for AT&T

Bodman Newest Member On Sandia Board

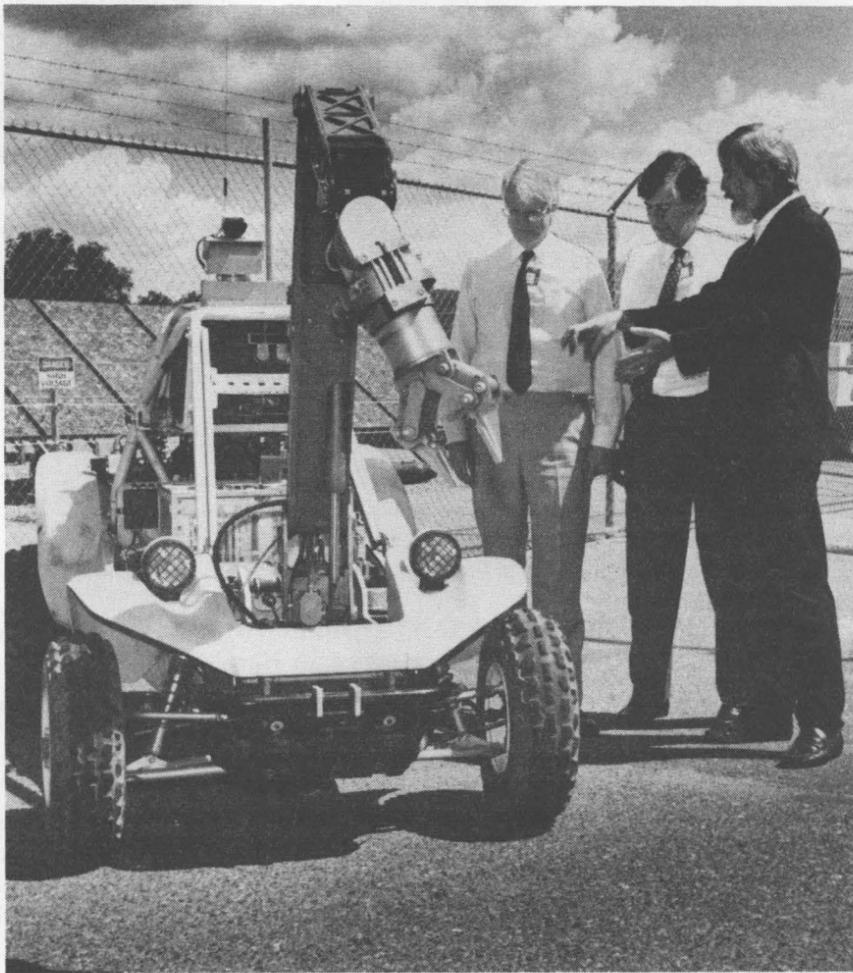
Richard Bodman, an AT&T Senior Vice President, has replaced Randall Tobias on the Sandia Corp. Board of Directors.

The 52-year-old Bodman replaced Tobias on the Sandia Board Aug. 1. He oversees AT&T's strategic planning and corporate development and is a member of AT&T's executive committee.

Bodman holds a BS in engineering from Princeton University and an MS in industrial management from the Massachusetts Institute of Technology. He has held positions on the boards of several corporations. Most recently, he was president of Washington National Investment Corp.

He has also held positions in the federal government as assistant secretary of the Department of the Interior and as assistant director of the Office of Management and Budget in the Office of the President. He is a Certified Public Accountant.

Tobias was given new responsibilities for AT&T's international business on June 25, just 5 weeks after his election to the Sandia Board. He now oversees all AT&T planning, development, and operations outside the US, part of an AT&T strategy to increase the company's share in the international telecommunications market.



RICHARD BODMAN, AT&T VP and newest Sandia Corp. Board of Directors member, visited Sandia, Albuquerque Aug. 30. Seen here at Sandia's Robotics Lab are (from left) Bodman; Waring Partridge, a consultant to AT&T; and Ray Harrigan (1414). Bodman replaced Randall Tobias on the Sandia Board Aug. 1. During his visit, Bodman also toured the Microelectronics Lab, the Process Development Lab, and met with many Sandians.

feed back

Q: When writing a new SOP (Standard Operating Procedure), it would be helpful if we had a list of current Sandia SOPs (not just generic ones, but all of them) to see if someone else has already written an SOP that could be used as is or as a model for a new one. This could save a lot of time and make it easier to comply with ES&H. Recently, I called several organizations to see if I could find a particular SOP, but no one seemed to know if one existed. Could a data base be set up to compile all SOPs and make them accessible by title, key word, or author? Or does such a list already exist?

A: A log of all generic and activity-specific ES&H SOPs is currently maintained by the Engineering Release Center in Design Information Management Dept. 2830. A complete listing of SOPs is sent quarterly to all directorate and VP ES&H coordinators. In addition, monthly lists of activity-specific SOPs are sent to the SOP-owning division supervisors. Contact your ES&H coordinator or Barbara Frames (2831) on 5-9568 to get a list of all SOPs.

The Engineering Release Center and the ES&H Directorate are studying the possibility of developing search capabilities based on key words, such as the hazards controlled by SOPs.

If you need a list of the old-style Safe Operating Procedures, call Theresa Kelly (7732) on 4-2443.

Nestor Ortiz (7700)

Q: Based on recent news reports (such as the June 3 issue of Time magazine) about the failure of some pension programs, I am concerned about the security of Sandia's retirement program should AT&T not renew its contract with Sandia at some point in the future. What guarantee do we have that what has happened to other retirement programs would not happen to Sandia's?

A: The assets of both Sandia's pension plans are held in trusts that are separate and distinct from the assets of either AT&T or Sandia Corp. Both plans are well-funded, and the trusts are managed for the exclusive benefit of pension plan participants as required by law. If AT&T did not renew its contract with DOE to operate Sandia, it would not have any claim to those pension assets. Likewise, any successive contractor operating the Labs would not have claim to those assets.

Both Sandia pension plans provide that, if the plans are terminated, any excess trust assets remaining after all vested benefits are guaranteed will revert to DOE. The companies cited in the Time article that you enclosed purchased annuities from financially troubled insurance companies primarily to increase the amount of surplus pension assets that could be recaptured. Any contractor managing Sandia's plan would not have a similar motivation because all surplus pension assets ultimately revert to DOE.

Ralph Bonner (3500)

Honored for Nuclear Security Achievements**Jacobs Named INMM Fellow**

James "Jake" Jacobs (7800) was named a Fellow of the Institute of Nuclear Materials Management (INMM) at an international annual meeting held several weeks ago in New Orleans.

The second Sandian to be so honored (J.D. Williams [9561] was named an INMM Fellow in



JAKE JACOBS

1990), Jake is one of the fewer than 5 percent of the Institute's total membership who are Fellows. The position of Fellow is awarded only to members who have made major contributions to the profession, have at least 15 years of experience, and have been a Senior

Member of INMM for at least five years.

Jake joined Sandia in 1959. He was one of several Sandians who in 1964 took leaves of absence to help Bellcomm, Inc., work on systems development for the Apollo moon-landing project. In 1968, he became Supervisor of the Advanced Component Development Division. From then until 1977, he supervised several divisions involved in guidance and control systems, secure

transportation systems, and security system integration. In 1977, he was promoted to Manager of the Advanced Systems Department.

He has also managed a DOE program instrumental in upgrading security at many DOE facilities. He was named Director of Nuclear Security Systems in August 1988 and became Director of Facilities 7800 on Aug. 1. Jake has been a member of the Army Science Board for 2½ years, and in 1990 was appointed vice chair of the board.

After many years as an active member of the Institute of Nuclear Materials Management, Jake received the 1985 INMM Distinguished Service Award. It was presented in recognition of his leadership role in the development and implementation of advanced physical security systems for nuclear materials at facilities and in transit.

In the period leading up to the service award, Jake formed and led a division involved in advanced development of SST-type (Safe Secure Transport) technology. He was program manager for the first high-tech security system implemented at Pantex, served on the robotics and artificial intelligence advisory board, and was advisor for the DoD Security Crisis Cell.

Jake's areas of professional interest include national security and defense, advanced conventional weapons, anti-terrorism and high-tech security, low-intensity conflict, battlefield systems, and robotics. ●DT

Take Note

The National Association of Corrosion Engineers (NACE) 1991 South Central Region Conference, hosted by the NACE Sandia Mountain Section, will be held in Albuquerque Sept. 23-25 at the Doubletree Hotel and the Convention Center. The technical program includes: "Corrosion in the Nuclear Industry," "Corrosion in Oil and Gas Production," "Cathodic Protection," "Coatings," "Microbiologically Induced Corrosion," and "Coal Seam Gas Production." The conference will include displays of industry goods and services, spouses' program, annual banquet, and social events. For a brochure and advance registration information, call or write NACE 91, 7609 Guadalupe Trail NW, Albuquerque, NM 87107, 898-5681.

Twice a year the Albuquerque Office of Senior Affairs and UNM Continuing Education Program sponsor classes that emphasize topics of interest to retirees, those about to retire, and family and friends who assist a senior citizen. Speakers from different agencies, such as the

Social Security Administration and the New Mexico Department of Human Services, present information that is beneficial to senior citizens. The classes meet from 10 a.m. to noon on seven Saturdays beginning Sept. 14 and ending Oct. 26. The first class is "Social Security, Medicare, and Supplemental Health Insurance for Seniors." Other topics include health maintenance organizations, community-based services, nursing home insurance, wills, guardianship, and funerals. For information, contact Medicare/Health Insurance Counseling on 764-6471 or 764-6474. To register, contact UNM's Division of Continuing Education on 277-6542; ask for course number 609. The fee is \$20.

Guy Trujillo of SunAmerica Securities, Inc., will present "What You Should Know About Retirement Before You Retire" on Sept. 25 at 5 p.m. at the Coronado Club Eldorado Room. The discussion includes estate planning, IRA rollovers, and retirement enhancement strategies. RSVP to Guy on 294-6655. Spouses are welcome.

BLACK STUDENTS from the Albuquerque area watch as glassblower Pat Farina (2476) joins Pyrex rods. The students were among 175 guests who visited Sandia last month on Historically Black Colleges and Universities (HBCU) Student Day. Patricia Salisbury (3511), Sandia's Black Outreach Committee chairperson, notes that the event recognizes Black summer interns who work at the Labs and gives Black high school students an opportunity to visit Sandia. Speakers included James Lewis, chief of staff for Gov. Bruce King and graduate of Bishop College, one of 107 HBCUs nationwide.

**First CRADA with a Company****Labs and Signetics Cooperate on R&D**

Sandia's Microelectronics Quality/Reliability Center will work with the Phillips Components/Signetics plant in Albuquerque in the first cooperative research and development agreement (CRADA) that the Labs has signed with an individual company.

Authorized under the National Competitiveness Technology Transfer Act of 1989, CRADAs are simplified agreements that permit a national laboratory to work with private companies to help them produce and improve their products.

Dan Arvizu, Director of Technology Transfer and Industrial Relations 4200, says the Signetics agreement is the first of many CRADAs that Sandia will sign with private companies. The Labs currently is negotiating with about 50 companies interested in signing CRADAs, he notes.

"This new way of partnering with industry significantly expands the ability to harness the Labs' broad technological capabilities to work with US-based companies in developing technologically superior products and increasing their international competitiveness," Dan says.

The Microelectronics Quality/Reliability Center (MQRC) was established to provide US industry access to microelectronics reliability testing and failure analysis capabilities that are not available elsewhere.

Ted Dellin, Supervisor of Reliability Physics Div. 2376 and coordinator of the MQRC, says the Signetics/Sandia CRADA will combine the Labs' unique capabilities with Signetics' expertise in high-volume integrated circuit manufacturing.

Ted explains, "Signetics will benefit by identifying reliability problems during product development, while Sandia will benefit by using Signetics' large product volume to get a better assessment of reliability test structures and models than is possible with Sandia's limited production for DOE and other government electronic systems.

"The Signetics CRADA is the result of a team effort by Reliability Physics Div. 2376 and Failure

"Sandia's [microelectronics] testing capabilities are not exceeded anywhere in the world."

Analysis Div. 2375," continues Ted. "Bill Filter [2376] will be the technical project leader for the Signetics CRADA."

Clint Anderson, Electronics Failure Analysis Manager for Signetics in Albuquerque, says, "We became interested in working with Sandia when we recognized the advanced technology capabilities at the Labs for quick characterization of microelectronics problems. Sandia's testing capabilities are not exceeded anywhere in the world."

Jon Macro, Manager of Signetics' Albuquerque Technology Development Applications Specific Products Group, says the CRADA, announced on Aug. 23 but signed earlier this summer, is already producing good results for the company. "It has accelerated our rate of problem solving," he says. ●AEtheridge(3161)

Sympathy

To John Gallegos (3121), Tom Gallegos (2481), and Rita Ann Padilla (221) on the death of their mother in Albuquerque, Aug. 6.

To Keith Gawith (2481) on the death of his mother-in-law in Albuquerque, Aug. 18.

To Ollie Davis (7821) on the death of his mother in Albuquerque, Aug. 18.

To Ray Cooper (2481) on the death of his sister-in-law in Roswell, Aug. 20.

Sandia News Briefs

State Honors Labs for Employing People With Disabilities

Sandia has been awarded the 1991 Job Training Partnership Act (JTPA) Outstanding Work Site Award by the New Mexico Department of Labor. The annual award recognizes one New Mexico employer that most exemplifies the goals and intent of the JTPA — to provide employment opportunities for disadvantaged people.

At an awards ceremony last week, Department of Labor representatives recognized Sandia's commitment to employing and training people with disabilities by contracting with Career Services for the Handicapped, a local not-for-profit employment service for people with disabilities, and by providing jobs for as many as 30 people with disabilities. Sandia's individualized training programs and flexible work schedules were also cited.

Linda Vigil-Lopez (3533), senior personnel specialist, says, "Career Services for the Handicapped is a valuable resource, and they've provided us with some outstanding people. We are proud to have them on our team." Sandia is now eligible to compete for a national JTPA award, to be awarded in December.

Hispanic Heritage Month Starts Sept. 16

This year's Hispanic Heritage Month activities begin with a kick-off lunch and program at Hardin Field (parade grounds) on Monday, Sept. 16, from 11:30 a.m. to 1 p.m. Labs President Al Narath will deliver opening remarks. Mexican food will be available, and the "Fiesta Marimba Band" will provide music for the event. Information booths will be set up by Sandia's outreach committees. All Sandia and KAFB employees, retirees, and their families are invited.

Other Hispanic Heritage Month activities planned in September and October (hosted by KAFB, DOE, and Sandia) include a benefit golf tournament and breakfast (Sept. 16); an opening ceremony featuring Special FBI Agent in Charge Bernardo Matt Perez (Sept. 17); the Fourth Annual Chile Cook-Off (Sept. 20); a lecture by Space Shuttle Astronaut Sid Gutierrez (Oct. 3); and a luncheon featuring Cari Dominguez, nominee for Assistant to the Secretary of Labor (Oct. 8). These activities will be detailed in a brochure to be distributed soon to all Albuquerque Sandians. For more information, contact Armando Castorena (3511) on 846-6251.

Sandia Paper for Modeling Electron Scattering Wins Award

Three Sandia researchers have received the 1991 Birks Award from the Microbeam Analysis Society (MAS) for their work modeling electron scattering in electron microscopy specimens. The award — given to Al Romig (1830), Joe Michael (1822), and Steve Plimpton (1421) — is for the Outstanding Paper presented at the 12th International Congress on Electron Microscopy, Analytical Sciences Division.

The paper examines the application of parallel computing to the Monte Carlo method, a modeling technique useful in electron microscopy for calculating the trajectories of electrons and analyzing microscopy X-ray data. This technique allows researchers to not only detect but also measure atomic-sized impurities in grain boundaries and compositional changes in phase interfaces no larger than a few nanometers (a nanometer is one millionth of a millimeter).

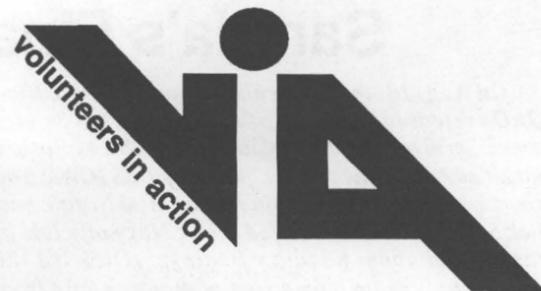
"Although the Monte Carlo technique has been studied for 20 years or more," says Al, "parallel computing could vastly improve its value as a real-time analytical modeling tool by reducing calculation time." The nCube 2, the parallel machine used in the Sandia research, can perform calculations 100 to 1,000 times faster than a conventional machine and 100 times faster than a conventional supercomputer such as the Cray-YMP, he says.

Sandia Device May Help Detect 'Illegal' Chemical Agents

Sandia researchers in Albuquerque and Livermore have developed a sampling device that could be helpful in US verification efforts for detecting concentrations of chemical warfare agents prohibited by international treaties.

Phil Hargis of Laser and Plasma Processing Div. 1128 and Larry Thorne of Program Development Org. 8300A developed a fluorometer that detects concentrations of complex hydrocarbon molecules in the air. It uses a small pump to draw air into a chamber irradiated by ultraviolet light. As the light inside the chamber scatters, its intensity (amplitude) pattern serves as a "fingerprint" of the molecules inside the chamber. In treaty verification efforts, it could be used to scan a given area and record where certain molecular species are concentrated, creating a so-called plume dispersal model.

Says Phil, "We expect to make a number of improvements that should increase its sensitivity by several orders of magnitude. Detection limits in the parts-per-billion range may well be possible." Phil says the fluorometer may be developed further so that remote measurements could be taken using lasers.



Volunteer Opportunities

Sandia's Volunteers In Action (VIA) program has received several requests for volunteers. Sandians or retirees who are interested in the following opportunities should contact Al Stotts, Community Relations Div. 3163, on 844-2282.

- **Tutors** — Volunteers are needed at several Albuquerque schools. At LAB NEWS deadline time, these schools had asked for volunteers: (1) La Cueva High School in all fields of math and science. Tutoring is done Wednesday evenings from 7 to 9. (2) Eldorado High School needs math, science, and writing-skills tutors for its Wednesday evening program that begins Sept. 18. (3) Albuquerque Technical-Vocational Institute (T-VI) needs tutors in electronics, physics, math, data processing, English grammar, writing, and biology at the main campus (525 Buena Vista Dr. SE) and at the Montoya campus (4700 Morris NE). Volunteers are needed for two-hour shifts at various times Monday through Saturday.

- **Technical Coaches for 1991-92 New Mexico High School Supercomputing Challenge** — This involves teams of students who will do computational projects in various science areas using high-performance computers at Sandia and Los Alamos national labs and elsewhere in the state. Each team will be guided by a teacher and a technical coach. Coaches should be familiar with the research area of the project and with computing. Coaches will help define a feasible project, direct students toward resources, provide technical information about science and math, monitor team progress, and help select the proper computing equipment and software. Coaches need to attend the opening workshop Oct. 24 and 25 in Albuquerque.

- **New Mexico Wildlife Federation** — Volunteers are needed for a special project this weekend, Sept. 7 and 8, to build a fence to protect a spring in the Cabezón area south of San Ysidro. The federation also needs a volunteer with accounting skills to help file non-profit quarterly reports with the IRS and State of New Mexico.

- **Zoo Docents** — The Rio Grande Zoo needs volunteer docents for a variety of activities. Docents take animals to young hospital patients, staff on-grounds "discovery stations," introduce school children to the animal kingdom, conduct guided tours, and travel around New Mexico in a zomobile, teaching children about conservation. •

Fun & Games

Golf — Winners of the Sandia Golf Association Member/Guest or Member/Member Tournament held at the Cochiti Golf Course on Aug. 10 were: A Flight — Mark Smith and Mike Spears, first; Ken Flynn (362) and Frank Ross (362), second; John Stanaloni (9141) and Dave Renninger (2114), third; Bob Wood (3712) and Bob Zaeh (3700), fourth; and Mark Retter (5126) and Mike Sjulín (5126), tied with Jim King (7818) and Roy Tucker for fifth; B Flight — Mike Heck (2334) and Kevin Heck, first; Julian Lovato (2855) and Duane Vermeire (2853), second; Floyd Salas (9322) and Rick Salas, third; and Joe Archuleta and Kim Law (2855), tied with Manny Chavez and Ron Hunt for fourth.

Results of the Valle Grande Classic held in Bernalillo Aug. 16 were: John Garcia (6423) and Luis Abeyta (7531), first; Daryl Dew and Bob

Platt, second; Don Wrobel (2542) and Fred Duimstra (ret.), third; and Lew Bartel (6258) and Carl Leishman (7412), fourth.

Congratulations

To Kristi and Brian (7713) Thomson, a son, Chase Montgomery, July 15.

To Linda and Steve (1513) Kempka, a daughter, Laura Elisse, Aug. 21.

To Darcy and Paul (9567) Klarer, a son, Christopher Steven, Aug. 23.

To Jennifer and David (1555) Outka, a son, Ryan Christopher, Aug. 26.

To Vicki (7723) and Ernest Gutierrez, a daughter, Jessica, Aug. 26.

Recent Retirees



Charles Riney
2345



Jack St. Clair
2716

32



Sandia's Final Report on the USS IOWA Explosion

On Aug. 28, the Government Accounting Office (GAO) released Sandia's final report to the Senate Armed Services Committee about the 1989 explosion that killed 47 crewmen on the battleship USS IOWA. The report was released as Sandia President Al Narath and Dick Schwoebel (300) briefed senior Navy officials in Washington about Sandia's findings. (Dick led the Sandia study team, composed of many people from throughout the Labs.)

Because the explosion and Sandia's inquiry into its possible causes have received considerable national attention and media coverage, the LAB NEWS is reprinting the complete introduction and executive summary from the final GAO report: Supplement to a Report to Congressional Requesters, USS IOWA EXPLOSION, Sandia National Laboratories' Final Technical Report. Sandians interested in examining the final report should contact the Technical Library Dept. 3140 on 845-8187.

The final report expands on the initial Sandia report completed in June 1990 and covered in detail in the June 15, 1990, LAB NEWS.

INTRODUCTION

On April 19, 1989, an explosion occurred on the battleship USS IOWA in the open breech of a 16-in. gun, killing 47 crew members. In its investigation of the explosion, the US Navy (USN) concluded there was evidence of "foreign material" in the cannellure of the rotating band that spins the projectile on firing. In this incident, the projectile was driven a short distance up the barrel by the open-breech explosion, but remained in the gun.

From subsequent open-breech tests the USN concluded that the "foreign material" was replicated only when a chemical ignition device was present. The USN proposed that the explosion was initiated by a chemical ignition device consisting of calcium hypochlorite, brake fluid (or similar material) and steel wool, and that it was placed by a crewman between the bags of propellant that were rammed into the gun. The USN report stated that "the residue found in the IOWA rotating band cannot be duplicated by simple contamination of the gun chamber with steel wool and other chemicals normally present in a gun firing."

In late 1989, the General Accounting Office (GAO) asked Sandia National Laboratories (SNL) to examine the adequacy of certain aspects of the USS IOWA investigation. On Nov. 22, 1989, Al Narath, President of SNL, agreed that Sandia would consult with the GAO and undertake a technical study, pending Department of Energy (DOE) authorization. Roger Hagengruber, Vice President of Defense Programs, was assigned responsibility for managerial oversight for this activity and for coordination with the DOE. Richard [Dick] Schwoebel, Director of Systems Evaluation, was assigned the technical lead. SNL was asked to: (1) examine pieces of rotating band and the 16-in. projectile from the gun for evidence of "foreign material" that might be related to a chemical ignition device; (2) test gunpowder from the USS IOWA's magazine and from the same lot obtained elsewhere to ascertain the stability of the material; and (3) review the scope and methodology of the USN's technical investigation and examine other physical evidence that the USN believed supported its conclusions about the probable cause of the explosion. SNL first reported its findings at a Senate Armed Services Committee hearing on May 25, 1990, and released its initial report, *Sandia National Laboratories' Review of the USS IOWA Incident, June 1990*.

The initial Sandia National Laboratories' report concluded: (1) the presence of a chemical ignition device could neither be proved nor disproved, although all the "foreign materials" except the steel wool fibers were shown to be normal components of battleship turrets; (2) the stability of both the propellant and black powder was within acceptable limits and there was only a remote possibility the black powder could have been initiated by friction, electrostatic discharge or electromagnetic radiation; (3) the powder bags were overrammed against the projectile and the extent of the overram was determined; and (4) that a potentially important factor in the explosion was a previously unrecognized sensitivity of the powder bag train to overram when there is a reduced number of pellets in the trim layer(s) of the powder bags. SNL experiments indicated that a reduced number of trim layer pellets lying next to the black powder pouch could result in an explosion if overrammed, and that the probability of an explosion increased with the speed of the overram. SNL recommended that these experiments be extended to actual 16-in. gun conditions to establish the validity of this ignition mechanism.

At the conclusion of the hearing before the Senate Armed Services Committee, SNL was asked to continue its work and to participate with the USN in the reopened

investigation of the incident.

This final report documents SNL findings of work performed since May 25, 1990. Detailed documentation of work described here will be found in SNL reports that were in preparation at the time this report was written.

EXECUTIVE SUMMARY

Introduction

Sandia National Laboratories' continued investigation of the explosion in the center gun in Turret 2 of the USS IOWA on April 19, 1989, has had three important thrusts.

The first has been to establish reference measurements for "foreign materials" found on the rotating band of the projectile in the center gun. These measurements were used to examine the US Navy's conclusion that these materials were the fingerprint of a chemical ignition device placed between the powder bags that were rammed into the breech of the gun.

The second has been to examine impact initiation of propellant caused by the fracture of pellets adjacent to a black powder pouch. These analyses were used to re-examine the USN's conclusion that "impact and compression of the bag charges were not contributing factors in the IOWA incident."

The third has been to further examine the overram that occurred in the center gun. This included studies of rammer motion as it was blown out of the breech, internal markings produced by the buffer in the rammerhead, powder bag compression and rammer handle motion. The results of these analyses were relevant to determining the extent of powder bag compression against the base of the projectile and helping to establish if a static overram occurred. In addition, analyses of the displacement of the rammer's seat have been used to better understand damage to the rammer handle quadrant.

The studies reported here have drawn heavily on the extensive USN investigation of the incident, and that work served as a valuable basis on which to extend certain elements of the SNL investigation. The SNL investigation did not include, for example, exhaustive studies of the operating mechanisms in the gun room such as the rammer, powder hoist and powder door. These mechanisms were found by the USN to be in proper operating condition at the time of the explosion and were apparently not associated with the cause of the explosion. An unexplained observation related to these mechanisms was the unlowered position of the powder car at the time of the explosion. This observation will be briefly discussed in the conclusion of this section of the report.

Foreign Materials

Further studies have shown that all of the so-called "foreign materials" found in the cannellure of the rotating band of the projectile in the center gun of Turret 2 are also found in the forward grooves of the projectile, i.e., in a region protected from the explosion. These materials are also found to varying degrees in the same regions of the projectiles that had been rammed into the left and right guns of Turret 2 prior to the explosion in the center gun. That is, the presence of "foreign materials" identified by the USN is not a unique indicator that the hypothetical chemical ignition device was present in the center gun.

1. The hypothetical chemical ignition device was postulated by the USN to be the source of iron fibers found on the rotating band of the center gun projectile. However, steel wool has been found in key locations on all three of the projectiles removed from the 16-in. guns of Turret 2.

2. Steel wool fibers found on the rotating bands of these projectiles cannot be distinguished from each other based on their morphologies. Size distributions of fibers found in various locations are also statistically indistinguishable. Compositional details of the steel wool indicated that it came from more than one source. That is, the steel wool apparently came from more than one pad of steel wool, not from a single pad as would be expected had a chemical ignition device been present.

3. Iron fibers found in the forward grooves of the rotating band of the center gun projectile are indistinguishable from fibers found in the cannellure. Fibers in the grooves could not have resulted from explosion products because the grooves were protected from the explosion by the seal formed by the rotating band fin. It is also unlikely that steel wool in the forward grooves could have resulted from contamination following the explosion because the grooves were sealed when the projectile was forced forward in the barrel.

Conclusion: Steel wool was found in the cannellures and forward grooves of the rotating bands of all three projectiles in the gun rooms of Turret 2. The steel wool in the cannellure of the projectile in the center gun was

indistinguishable from that found in forward grooves, and was also indistinguishable from that found on the other two projectiles. The observation of iron fibers in the rotating band of the projectile from the center gun is not a definitive indicator of the presence of the hypothetical chemical ignition device.

4. Ballistics modeling indicates that iron fibers of the size found in the cannellure would have been physically altered by the high-temperature explosion. Had any fibers been deposited in the cannellure, it is expected that they would have had a melted appearance and exhibited rounded surface features consistent with exposure to temperatures in excess of the melting point. None of the fibers recovered from the cannellure of the center gun projectile had such an appearance. Ballistics modeling also indicates that the flow of rapidly expanding gases from the point of ignition would tend to carry fibers away from the cannellure. This modeling is consistent with the observation that very few steel wool fibers were found in the rotating bands of projectiles used in full-scale tests in which a chemical ignition device was used to initiate an explosion.

Conclusion: The physical appearance of fibers found in the cannellure is not consistent with that expected of fibers exposed to temperatures above the melting point. The relative absence of steel wool in the cannellure following full scale field tests using a chemical ignition device to initiate an explosion is consistent with ballistics modeling that predicts the general flow of gases away from the cannellure. These and other results regarding fibers suggest that the steel wool in the rotating band of the center gun projectile was present before the explosion and is unrelated to its cause.

5. The presence of an encrusted iron fiber in the cannellure was emphasized by the USN as being a unique signature of the presence of a chemical ignition device based on their field tests. USN measurements of higher-than-normal quantities of calcium on a single encrusted fiber were not corroborated because that fiber and any similar ones were not available for analysis by SNL.

Conclusion: The encrusted fiber described in the USN report appears to be one of a kind and is not representative of the many other fibers found in the cannellure.

6. With the exception of the single encrusted fiber, all measurements of the surface quantities of chlorine and calcium on iron fibers taken from the cannellure of the center gun projectile are comparable. These quantities are similar to the surface quantities of these elements observed on iron fibers from the projectiles that were in the left and right guns of Turret 2. These quantities are also similar to those found on fibers recovered from the forward grooves of the rotating band from the center gun projectile, i.e., fibers that were isolated from the explosion. Substantially higher quantities of chlorine were measured on iron fiber and cannellure surfaces of projectiles from field tests using chemical ignition devices than on fibers taken from the cannellure of the center gun projectile.

7. Debris and grease from the forward grooves and cannellures of projectiles from the left and right guns of Turret 2 contain significant levels of calcium and chlorine. These levels are similar to the levels found in the debris taken from the cannellure of the center gun projectile.

Conclusion: The observed quantities of chlorine and calcium on iron fibers and in debris from the cannellure of the center gun projectile are similar to the quantities of these elements on iron fibers and in debris found elsewhere in the turret. The observed quantities of calcium and chlorine are not definitive indicators that the hypothetical chemical ignition device proposed by the USN was present in the center gun. If a device of this kind had been present, substantially higher quantities of chlorine on surfaces of fibers in the cannellure would have been expected based on USN field tests.

8. The USN found glycols in the cannellure and concluded that they were constituents of brake fluid or a similar material that may have been used in the hypothetical chemical ignition device. It has been found that these same glycols are present in Break-Free™, a liquid routinely used to maintain the 16-in. guns on the USS IOWA.

9. A large quantity of Break-Free™ was used to help remove the projectile from the center gun following the incident. Break-Free™ apparently leaked into the cannellure, contaminating it with several of the constituents that the USN concluded came from the hypothetical chemical ignition device.

10. These glycols are also constituents of grease residues found on other projectiles from Turret 2.

Conclusion: The glycols are constituents of Break-Free™ used in the routine maintenance of the guns, and

(Continued from Preceding Page)

are also found in grease residues on the projectiles. A large quantity of Break-Free™ was used to help free the projectile and apparently leaked into the cannellure. The presence of these glycols does not demonstrate that the hypothetical chemical ignition device was present.

11. The USN postulated that a single PE-PET [polyethylene-polyethylene terephthalate] fragment, believed to have been found in the projectile's cannellure, came from a plastic food bag that contained the hypothetical chemical ignition device. It has been found that the sampling procedure used by the USN did not document that the fragment came from the cannellure of the projectile. Further study also shows that Dacron™ fibers covered with Break-Free™ can produce a P-GC/MS [pyrolysis gas chromatography/mass spectroscopy] spectrum indistinguishable from that of the PE-PET fragment identified by the USN. Such a fragment could have come from several sources, including the Dacron™ bore brush sock used to clean the gun.

Conclusion: The USN did not document that the PE-PET fragment came from the cannellure of the projectile. The PE-PET fragment does not support the presence of the hypothetical chemical ignition device.

12. SNL found inorganic particulate materials in debris from the forward grooves of projectiles from the center gun and one other gun in Turret 2. These particulates were similar to many of the materials identified in the cannellure of the center gun projectile and included paint chips, sand and/or glass, metal fragments, iron fibers, and high-temperature graphite.

13. The high-temperature graphite particles found in the cannellure and forward grooves of the center gun projectile and the forward grooves of IG-2 are indistinguishable from graphite inclusions in the cast iron projectiles.

Conclusion: Similarities in the inorganic particulate found in both the forward grooves and the cannellure of the projectile from the center gun also suggest that this debris, along with the steel wool, was present before the explosion. The observation of inorganic particulate does not support the presence of the hypothetical chemical ignition device.

Overram of Powder Bags

In normal operations, the powder bags are pushed slowly with the rammer (1 to 2 ft./sec.) until the rear of the last bag is just inside the breech of the gun. For a five-bag charge, such as was used at the time of the incident, this leaves a space of at least 17 in. between the front of the bags and the base of the projectile. In the USS IOWA incident, it was found that the powder bags were overrammed so that there was no space between the bags and the projectile.

1. The position of the rammerhead at the time of the explosion was determined by correlating gouges in the spanning tray with specific links in the rammer chain. The overram was determined to be 45.75 ± 0.1 in. beyond the breech face if there was no compression of the rammerhead buffer, or 48.25 ± 0.1 in. if there was full compression of the buffer.

Conclusion: The extent of the overram was approximately 5.5 in. beyond that determined by the USN, and compressed the five powder bags approximately 1.1 in. against the base of the projectile. A substantial overram of the powder bags occurred in the center gun.

2. The USN observed after the explosion that the rammer handle was in a position corresponding to a ram speed of approximately 1.7 ft./sec. and concluded that ramming occurred at normal speed. However, possible collision of the rammer's seat with the rammer handle and transients introduced into the rammer system by the explosion could have produced substantial movement, resulting in virtually any position of the rammer handle after the explosion.

Conclusion: The position of the rammer handle following the open breech explosion cannot be definitely related to the ram speed prior to the explosion.

3. The USN has suggested that ramming took place at slow speed based on marking of the quadrant by impact of the rammer's seat. SNL analyses of the rammer's seat motion show that the first impact of the seat occurs with the aft quadrant mounting pad. This appears to be supported by a photograph of this region of the quadrant mounting pad. In addition, these analyses show that the aft leg of the seat contacts the rammer control lever. Both of these contacts occur before the front of the seat has rotated sufficiently to cause impact with and marking of the quadrant.

Conclusion: The marking of the quadrant is not a definitive indicator of ramming speed because the quadrant could have been dislodged from the bulkhead by the impact of the seat. In addition, the rammer lever could also have been moved prior to the marking of the quadrant.

4. Measurements by the USN have determined the

average uncompressed length of five powder bags and the nominal projectile seating distance. A refined dynamic model by SNL has been used to show that it is impossible to establish the speed of the overram because of the large variability in the length of the powder bags.

Conclusion: The uncertainties of powder train length and projectile seating distance makes it impossible to determine the rammer speed from the compression of the powder bags and the gouges in the spanning tray.

5. The SNL interpretation of gouges on internal surfaces of the buffer in the rammerhead is that the buffer was 1/4 in. short of full compression when the open breech explosion occurred. That is, the buffer was not fully compressed at the time of the explosion. However, it was observed in one of the open breech field tests that the statically held rammerhead moved forward after ignition but prior to the blast.

Conclusion: The buffer marks cannot be used to conclusively determine the speed of the overram.

Initiation Sensitivity

1. The propellant and black powder were both found to be within the acceptable range of stability. Stabilizer levels in propellant pellets were also within acceptable limits based on USN requirements. SNL evaluations indicate that the possibility that the explosion could have been caused by electrostatic discharge, electromagnetic radiation, and thermal or friction effects is negligible.

Conclusion: The age and stability of the propellant and black powder were not factors in this explosion.

2. A powder bag is brought to the correct weight by placing several pellets on their side in a trim layer at the front of a powder bag. SNL postulated from reduced-scale tests that powder bags in 16-in. guns could be initiated by a high-speed overram, a process that can fracture pellets in the trim layer of one bag, igniting the black powder pouch of the adjacent powder bag. The USN confirmed this effect in full-scale tests.

Conclusion: Trim layer pellets fractured by a high-speed overram can ignite the black powder of the adjacent powder bag and lead to an explosion.

3. It was found that trim layers containing one to approximately 12 pellets are more sensitive to ignition in an overram than trim layers containing larger numbers. The lot of D846 propellant aboard the USS IOWA at the time of the explosion included bags with trim layers containing from zero to sixty-three pellets. The distribution of the trim layer pellet count was such that, in five bags randomly selected from this lot, the probability was 0.166 (one in six) that one or more of the rear four bags would contain from one to 12 pellets in the trim layer.

Conclusion: The probability was 16.6 percent (one in six) of selecting a group of five-bag charges from the propellant lot aboard the USS IOWA that was sensitive to ignition to overram.

4. The probability that an overram at 14-ft./sec. will initiate a five-bag powder train that includes at least one bag with one to 12 trim pellets is nominally 0.087 (one in eleven). Given the statistical uncertainties, this probability could be as high as 0.39 (approximately one in three). These probabilities were calculated using data provided by the USN from full-scale studies in a gun simulator and also data from the other (approximately 600) tests.

Conclusion: The probability of initiating a five-bag powder train with at least one bag with one to 12 trim pellets is nominally 0.087 (one in eleven) in a high-speed overram.

5. The probability of an explosion in a high-speed overram is the product of the probability of having a sensitive combination of powder bags (that is, at least one powder bag with one to 12 trim pellets next to a black powder pouch) and the probability of initiating such a combination.

Conclusion: The probability of an explosion in a high-speed overram was nominally 0.0144 (one in 70) for five powder bags randomly selected from the lot aboard the USS IOWA at the time of the explosion. Given the statistical uncertainties, the probability could be as high as 0.0639 (one in 16).

6. There is another sensitive configuration of pellets that does not involve the trim layer. Initiation occurred in one of five full-scale tests at high ramming speeds when a single pellet was misplaced at the rear of the bag adjacent to the black powder pouch. Subsequent examination of all the D846 propellant bags showed that 3.39 percent of them had a misplaced pellet at the rear of the bag. There may be even more sensitive configurations that can lead to initiation of an open-breech explosion in an overram situation.

Conclusion: The presence of a reduced number of pellets in a trim layer is only one configuration that can lead to an explosion in an overram. At least one other configuration, the single misplaced pellet at the rear of

the bag, can also lead to an explosion. The probability of explosion with this and other configurations has not been fully explored.

Summary

The following summary statements of the SNL investigation are presented with respect to the USN conclusion that a chemical ignition device was placed between the powder bags by the gun captain and then initiated by a static overram.

The USN reported that "the residue found in the IOWA rotating band cannot be duplicated by simple contamination of the gun chamber with steel wool and other chemicals normally present in a gun firing." This included the presence of calcium, chlorine, various glycols, inorganic particulate, and steel wool fibers found in the cannellure of the center gun projectile and associated by the USN with a hypothetical chemical ignition device. Studies at SNL show that the foreign materials identified by the USN in the cannellure of the projectile of the center gun are indistinguishable from those found in other key locations within Turret 2. Chemical constituents and steel wool fibers indistinguishable from those in the cannellure were found in the forward grooves of the rotating band of the projectile in the center gun; that is, in a region of the cannellure that was isolated from the explosion. In addition, the same chemical constituents and steel wool fibers were also found in the cannellures and forward grooves of the rotating bands of projectiles that were in the left and right guns of this turret. These fibers were also indistinguishable from those in the cannellure of the center gun projectile. These and other facts suggest that the fibers and the various chemical constituents found by the USN on the center gun projectile are unrelated to the explosion.

A substantial overram of the powder bags occurred for reasons that have not been determined. That is, the powder bags were forced against the base of the projectile by the rammer. This was determined from an analysis of the position of gouges on the spanning tray. Based on the observation that the buffer in the rammerhead was apparently not fully compressed at the time of the explosion, the overram may have occurred at higher-than-normal speed. A further observation that tends to support the concept of a higher-than-normal-speed overram was the unlowered position of the powder car. The normal procedure aboard the USS IOWA was to lower the powder car immediately after closing the powder door. If the ramming of the powder bags occurred at high speed, the upper powder hoist operator may not have had time to begin the lowering of the car. If the ramming occurred at low speed, the operator would have had about 20 to 30 seconds to begin this process.

After the explosion, the rammer control handle was found in the 1.7 ft./sec. position. However, SNL analyses show that the position of the handle and damage to the quadrant are not definitive indicators of the ramming speed.

It has been demonstrated in a full-scale simulator that a high-speed overram can initiate powder bags and result in an open-breech explosion. This previously unrecognized safety problem with 16-in. guns occurs when hot particles from fractured propellant pellets ignite nearby black powder. While impact initiation cannot be proven to have been the cause of the explosion, these results raise serious questions about the USN conclusion that "impact and compression of the bag charges were not contributing factors in the IOWA incident." Impact initiation could have been involved since a significant overram occurred.

A variety of scenarios for this incident have been explored, but they remain unproven for lack of evidence, partially due to the violence of the explosion and fire. Because of this, it may be difficult to ever fully resolve the many unknowns and develop a clear and unambiguous explanation of the events that occurred within the center gun room of Turret 2.

It is concluded that there is no explicit physical evidence that the hypothetical chemical ignition device was present in the center gun of Turret 2. It is also concluded that a high-speed overram is a possible cause of the April 19, 1989, explosion aboard the USS IOWA.

Recommendations

Following are recommendations if future operation of 16-in. guns aboard the battleships is anticipated:

1. Mechanisms for positive control of rammer speed and distance should be implemented as recommended in the interim report.

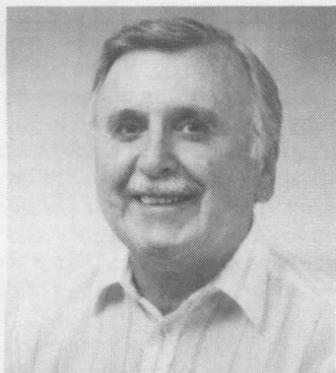
2. Various other pellet displacements, including those at the rear of the powder bags, should be explored to determine if there are additional sensitive configurations that could lead to an explosion in an overram.

The USN has already implemented an earlier recommendation that powder bags be redesigned to eliminate trim layers.

MILEPOSTS

LAB NEWS

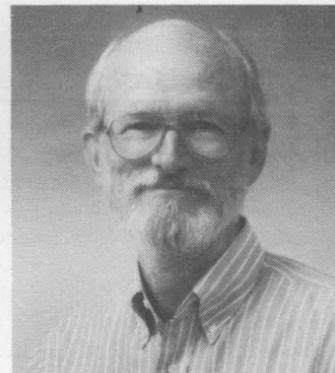
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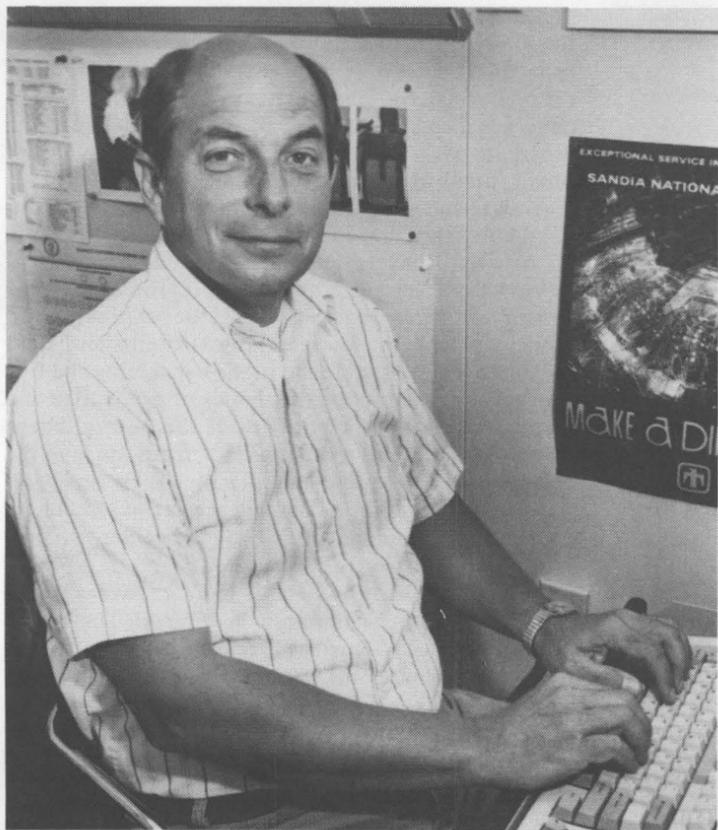
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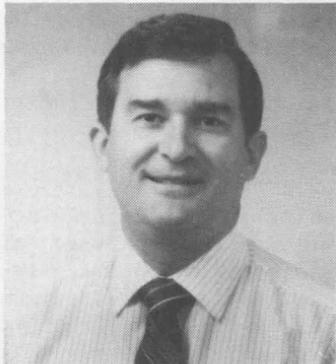
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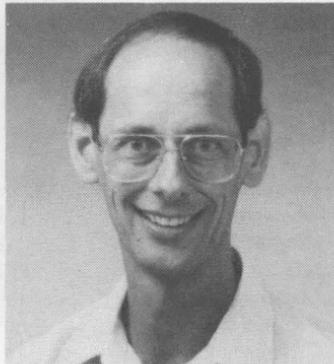
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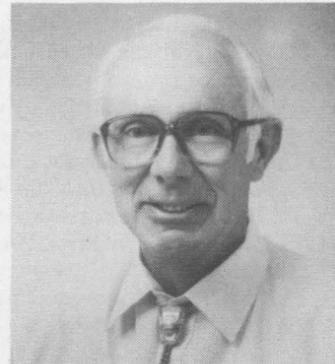
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Larry Grube
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Thomas Hinkebein
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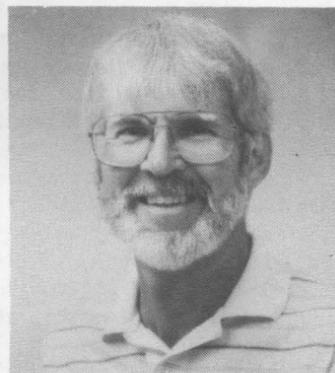
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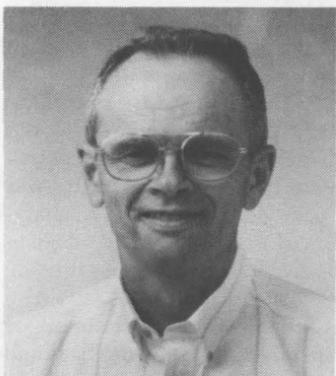
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Michael Sharp
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John Rosborough
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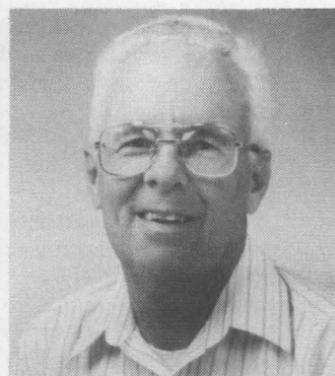
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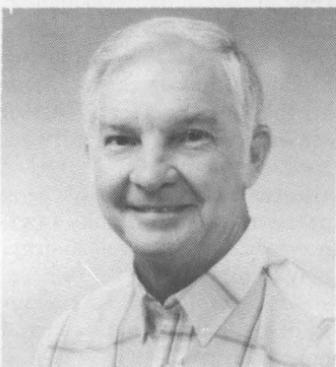
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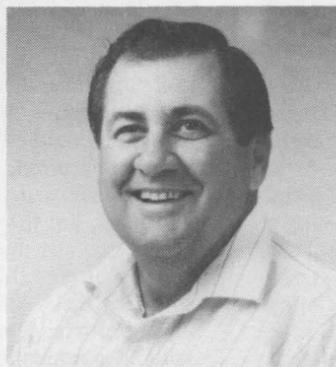
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Dorsey Bishop
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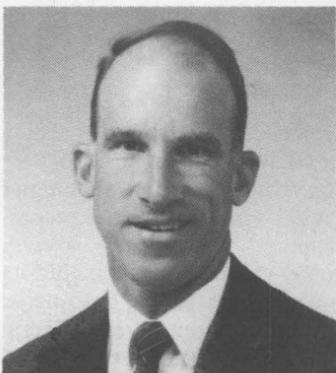
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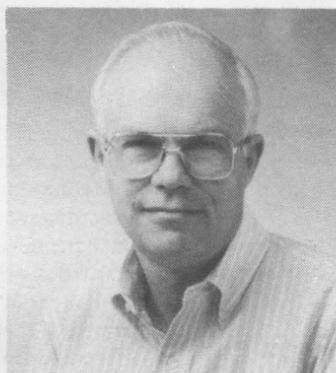
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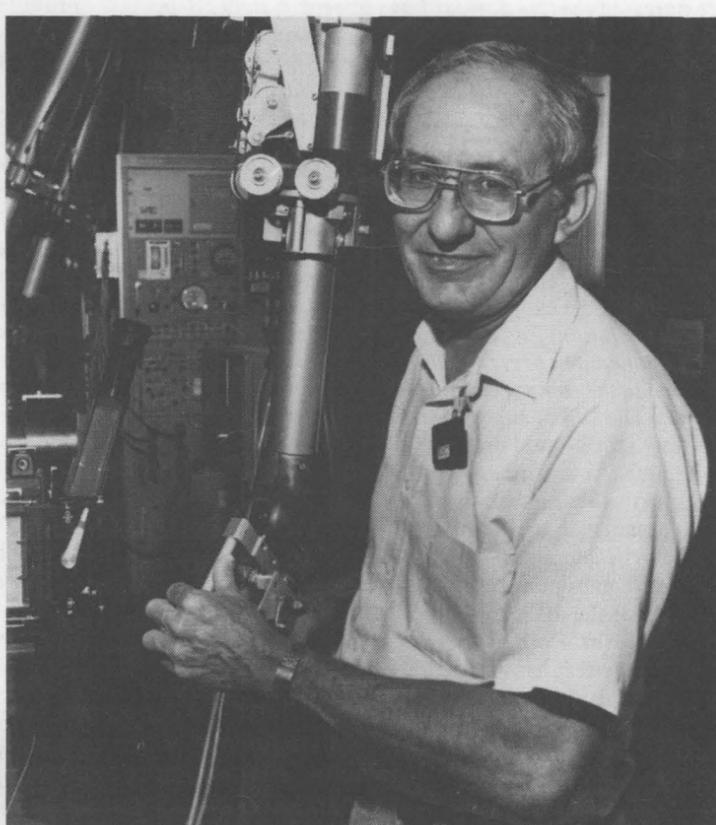
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Charles Miller
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Frank Gonzalez
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Deadline: Friday noon before week of publication unless changed by holiday. Mail to Div. 3162.

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.
13. "Work Wanted" ads limited to student-aged children of employees.

MISCELLANEOUS

TRAVEL TRAILER, '90 Terry Resort, 22-ft., loaded. Brigham, 292-4399.

STEREO POWER AMP, Yamaha P-2200, 230WRMS/Channel @ 8 ohms, .05% THD. Jewell, 892-6373.

MATERNITY CLOTHES, fall/winter, size 12-14: sweaters, \$7; blouses, \$6; pants, \$5; overalls, \$7; other items. Snyder, 293-3611.

ANTIQUA SOFA, Duncan Phyffe, floral print, \$295 OBO. Castillo, 294-5182.

AIR CONDITIONER, window-type swamp cooler, \$40. Tobyas, 877-0354 after 6 p.m.

KEYSTONE GOLD TEN RIMS (4), 4-hole, w/4 P185-75-R14 radial whitewall tubeless tires, \$75 firm. Gonzales, 344-4933.

AM/FM CASSETTE CAR RADIO, new, \$55; removable car mirrors & air deflector, for pulling a trailer, \$35. Cropp, 296-1877.

WHITE CRIB, \$135; bed set, \$45; high chair, \$75; car seat, \$20; refrigerated air conditioner, \$75. Simpson, 298-1277 or 265-4670.

MERCURY OUTBOARD MOTOR, 6-gal. gas tank, \$20; rowing machine, \$50. Patrick, 265-4569.

BRUCE PREFINISHED OAK FLOOR, 140 sq. ft., \$300 OBO; 48-in. oak bathroom vanity, new, \$300 OBO; Coleman gas lantern, \$35. Luther, 293-4462.

AQUARIUM, 10-gal. show tank, w/dual filter board systems, vacuum, other accessories, \$25. Hollister, 296-8055.

BUTCHER BLOCK SOFA & CHAIR, solid, dark pine, w/rust southwest print, upholstered cushions, \$200. Thibeau, 281-5143.

YAMAHA TENOR SAX, accessories, \$675; Reynolds trumpet, 2 mouthpieces, \$200. Aragon, 888-3473.

IRRIGATION PUMP, Sears, 3-hp, overhauled, \$250; 4 rims from '85 Berlinetta Camaro, includes caps, lugs, & locks, \$175/all. Zamora, 865-6280.

OSCILLOSCOPES, Tektronics 545 or 555, 30Mhz, dual-beam, guaranteed, \$80; VTVM and signal generator, \$25/ea. Frost, 293-4676.

SKIS: Dynastar, 175cm, w/M36, used twice, \$250 OBO; Rossignol 170cm, \$70; Elan 130cm, \$25. Plummer, 296-4327.

UPRIGHT FREEZER, Whirlpool, \$100. Romero, 298-7934.

LIVING ROOM SET, 3-piece, plus rocker-recliner, \$300. Sanchez, 292-1982.

YARD SALE, annual neighborhood sale, Sat., Sept. 7, Chelwood Gables (SW corner of Indian School & Chelwood NE), 8 a.m.-3 p.m. Barnette, 292-5186.

HEATHKIT, 2 ea. H8 microcomputers, H9 & H19 terminals, dual H17 disk drives, H14 line printer, manuals, software, \$450 OBO. LeGalley, 822-0676.

REDSKINS FOOTBALL JACKET, size large, \$100 OBO. Romero, 873-3652.

ANTIQUA GAS STOVE, Oxford Universal, green marble & ivory porcelain finish, still works, \$350. Sisneros, 898-0156.

BEIGE CARPET, 20x20, new, \$200; double laundry tub, porcelain, \$25. Brandon, 836-5621.

KODAK CAROUSEL, Model 750H, w/5-in. lens & 50x50 Da-Lite projection screen, both in original boxes. Wagner, 823-9323.

GOLF CLUBS, full set Power-Bilt Citation persimmon woods & matching irons, new grips, \$175 OBO. Guitierrez, 275-9345.

CHEVEL MIRROR, Ethan Allen, maple, \$150; solid oak studio-size easel, \$150; maple bedroom chair, \$30; all OBO. Ramel, 821-0475.

HP DESKJET PLUS, 300-dpi ink-jet printer, laser-quality on plain paper, serial & parallel, \$375. Sjaardema, 299-8042.

'87 JET SKI, \$2,500 firm. Lewis, 291-8181.

CUSTOM TOPPER CAMPER SHELL, 5' x 6', w/roof rack & tinted sliding windows, fits short-bed import trucks, \$275. Brown, 298-1303.

KIRBY VACUUM CLEANER, Heritage model, w/all attachments plus rug shampoo, \$75 OBO. Kubiak, 265-6525.

GOSLING, free to good home. Bauer, 266-8480.

MAPLE CRIB, \$200; TurboTronic vacuum, \$60; Panasonic computer printer, \$100; high chair, \$12; Gerry monitors, \$15. Cordes, 299-0511.

COLOR TV, 19-in., cable-ready, remote control, \$100. Croessmann, 262-0444.

CAMPER SHELL, fiberglass, currently mounted on a Datsun pickup, \$100. Baca, 275-2049.

SOLAR PANEL, w/hot water heater, never used, \$300 OBO. Rea, 296-4620.

KING-SIZE WAVELESS WATERBEDS: English 4-poster w/6 drawers, dark pine, \$250; contemporary light oak w/mirrored bookcase headboard, \$250. Miller, 275-1609.

WASHER & DRYER, \$250. Gabaldon, 293-9562.

BEDROOM FURNISHINGS: white enameled steel twin bed, student desk w/hutch, 2 bookcases, comforter & sheets (for girl). Loehman, 265-3179.

WARD'S REFRIGERATOR, 22 cu. ft., 3-door, side-by-side, ice maker, needs recharge (\$125), harvest gold, \$200. Strascina, 294-0305.

TWO-HORSE TRAILER, 2-axle, Miley-Circle M; western saddle; new Amish harness. Williams, 298-2624.

WHIRLPOOL WASHER AND GAS DRYER, have been in storage for two years, \$250. Carpenter, 294-1372.

TANDY 1000SX COMPUTER, 640K RAM, 20-Meg. HD, color monitor, one floppy, w/Epson FX85 dot-matrix printer, \$600. Davis, 298-3342.

SMITH & WESSON .357-MAG, Model 28 Highway Patrolman pistol. Schaub, 865-8807.

VITO CLARINET, case & music stand, \$110. Thalhammer, 298-8521.

HOT TUB, family-size, '86 Sundance Supra Lounger model, 7' x 7', fully-equipped, \$3,500. German, 281-1719.

DRESSER, solid wood, \$125, attaching etagere, \$100; restored hinged-top school desk, w/attached swivel seat, \$40. Scharnberg, 345-1523.

COMPUTER, 286-10MHz, 1Mb RAM, 20Mb hard drive, 1.2Mb & 360Kb 5-1/4-in. floppy drives, monochrome monitor, \$580. Balk, 281-9083.

COUCH KIT for full-size long-bed Ford & GMC trucks, \$175. Draelos, 296-3078.

GARAGE SALE: 3-family, Sept. 7, 9 a.m.-2 p.m., furniture, clothes, knick-knacks, more, 8817 Cherry Hills Dr. NE (Wyoming north to Harper, east). Ater, 845-5097.

CELLO, w/case, full-size, Kay student model, \$425; patio door, 8-ft., double-pane, \$50 OBO. Guess, 881-6498.

BEDROOM SET: white & oak veneer, single bed/mattress, \$500 OBO. Bartberger, 823-2843.

BOX SPRING, twin-size, Sealy brand, \$40. Moore, 268-6834.

AGU MOTORCYCLE HELMET, worn once, size 56, \$125. Kovacic, 256-9867.

NEW 1/3-HP FAN MOTOR; fluorescent light; Yamaha skis; Salomon bindings; Hanson boots; poles; Monroe electrical/mechanical calculator. Switendick, 255-1003.

COMPUTER TABLE, printer stand, & corner unit, made by Bush, black w/dark wood-color trim, \$150. Lunsford, 296-0976.

DOT-MATRIX PRINTER, Panasonic KX-P1592, wide-carriage, \$200. Levan, 293-0079.

GERMAN SHEPHERD, female, s-payed, black & tan, 5 yrs. old, needs good home. Hernandez, 843-7135 evenings.

MICROWAVE OVEN, full-power, full-size, brown, Amana, \$80; red-wood picnic table, w/2 benches, \$75. Korbin, 821-8461.

STEPPING MACHINE, Precor 714/718e, low-impact climber, used one month, \$350 new, sell for \$200. Snow, 266-8232.

EXERCISE BICYCLE, DP Air Gometer, w/8-function monitor including pulse rate, \$160; Porta Potti, "Continental," \$65. Owyong, 294-1884.

MACINTOSH 512K COMPUTER, complete system, ImageWriter printer, 3-1/2-in. external disk drive, word processor & graphics software, \$600. Oberkamp, 292-4366.

QUEEN-SIZE SOFA SLEEPER, \$100; white Hush Puppie oxfords for band, size 9, worn twice, \$35. Smith, 293-3296.

PING EYE-2 WOODS, 1, 3, & 5 ZZ-Lite shafts, new, \$200, plus 2-iron, \$50; Wilson woods, \$48; "Ginty" wood, \$40. Stang, 256-7793.

TRANSPORTATION

'90 KAWASAKI KLR650, on/off road, \$2,850; '77 Suzuki GS750, \$700. Brigham, 292-4399.

'65 KARMAN GHIA, classic, one owner, new engine, \$5,900; '67 Mercury, \$2,800. Cropp, 296-1877.

'84 CHEV. CAVALIER, type 10, 2-dr. hatchback, AT, AC, PS, PB, 71,500 miles. Rodacy, 293-2668.

'78 F-150 PICKUP, V-8, PS, AC, long-bed, 78K miles, \$1,500. Hartwig, 298-5048.

MAN'S BICYCLE, LeGrande 12-spd., \$60. Patrick, 265-4569.

'71 BUICK SKYLARK, V-8, AC, PS, PB, vinyl top, 150K miles, \$1,000. Petraglia, 889-0725.

'81 FORD F-350 XLT, 4x4, loaded, \$5,000. Thibeau, 281-5143.

'83 MAZDA B2000 PICKUP, 5-spd., top, bedliner, 60K miles, new brakes, one owner, \$1,500 OBO. Schunk, 275-2321.

'81 TOYOTA CELICA LIFTBACK GT, AT, AC, PS, PB, stereo tape deck, AM/FM, 97K miles, \$2,500. Miyoshi, 821-9118.

'86 FORD AEROSTAR XLT, dual AC, AM/FM, digital dash, AT, PS, PB, cruise, tilt, sun screen, 65K miles, \$7,000. Yarrington, 823-6648.

'84 DODGE COLT, new tires & brakes, passed emissions, best offer. McCoach, 296-6319.

'84 FORD BRONCO II, two-tone paint, 80K miles, \$4,250. Roberts, 299-5671.

WOMAN'S BICYCLE, Raleigh Marathon, 21-in., Mixte 12-spd., 4 yrs. old, less than 70 miles, \$125. Wiley, 883-7280.

'76 BROUGHAM MOTORHOME, 24-ft., 318 V-8 engine, Dodge chassis, 48K miles, all options, second owner, records, \$8,500 OBO. Sparks, 884-7376.

'86 VOLKSWAGEN JETTA GL, 76K miles, 5-spd., AC, PB, PS, sunroof, Blaupunkt AM/FM cassette, \$4,700. Cummings, 292-0524.

'84 TRANS AM, 305 Hi Pro engine, 4-spd., AT, T-top, 61K miles, \$3,500; '65 Ford pickup, 3/4-ton, new brakes, \$2,500. Brandon, 831-0729.

REPOS: '87 Acura Integra LS, 5-spd., 4-cyl., AM/FM stereo tape deck, AC, 62,757 miles; '89 Chev. Camaro RS, 5-spd., 6-cyl., AC, AM/FM stereo, 36,383 miles; bids accepted through Sept. 12; we reserve the right to refuse all bids; subject to prior sale. Sandia Lab FCU, 293-0500.

'85 VOLKSWAGEN JETTA GL, AT, AC, AM/FM, 86K miles, \$2,700 OBO. Mills, 897-2817.

'87 TAURUS LX, V-6, new tires, electronics group, loaded, warranty through Oct. 1992, one owner, garage-kept, \$7,000 OBO. Zaorski, 281-9194.

'84 TOYOTA VAN LF, AT, dual AC, \$4,500 OBO. Padilla, 899-1913.

'84 HONDA MAGNA V30 MOTORCYCLE, 4-cyl., 16-valve water-cooled engine, windshield, backrest, 8,400 miles, adult-ridden, garage-kept, \$1,595. Schkade, 292-5126.

HONDA SHADOW MOTORCYCLE, 700cc, V-twin, shaft drive, water-cooled, 5-spd. w/OD, 6K miles, garage-kept, adult-ridden, extras. Bray, 292-2410.

WOMAN'S RACING BIKE, 10-spd. Raleigh, \$75; woman's 3-spd. Schwinn, \$40 OBO. Scharnberg, 345-1523.

'70 VOLKSWAGEN BUG, Baja, AM/FM cassette, rebuilt engine, new clutch, \$1,800. Perrine, 293-1429.

'84 TIAGA MOTORHOME, 23-ft., Class C, double dinette, generator, deluxe interior, Chev. power, 37K miles, \$18,000 OBO. Ater, 822-9697.

'62 CORVAIR MONZA 900 SEDAN, 35K miles on 6-cyl. factory engine, rebuilt AT, needs paint, upholstery, \$1,200. Roose, 296-4129.

'88 JEEP COMANCHE, 4.0 metric tons, 35K miles, PS, PB, tilt, bed liner, rack, tinted windows, more. Garcia, 344-3406.

PEUGEOT 10-SPD. BICYCLE, \$75. Kovacic, 256-9867.

'76 DREAMLINER MOTORHOME, 25-ft., roof air, generator, 440 engine, 37K miles, \$8,000, will consider truck camper for partial trade. Rose, 881-8747.

'84 HONDA V-35 MAGNA, 8K miles, \$800; '85 Honda XR200R, \$700. Szklarz, 292-3995.

REAL ESTATE

4-BDR. HOME, mountain living, 2,175 sq. ft., 2 baths, 1.2 acres, large decks, views, 20 min. east of Albuquerque, \$157,500. Lyons, 281-9283.

1.3 ACRES, El Pinar Estates, 14 miles east of Albuquerque, off frontage road, wooded, electricity, phone lines on property. Perryman, 281-3020.

MOUNTAIN CABIN, 1-1/2 acres, 1,400 sq. ft., hunting, fishing, furnished, inside facilities, electricity, Pecos, N.M. area, \$45,000. Torrez, 298-4611.

10 ACRES, 3.5 miles south of Moriarty, on school bus route, set up for double-wide, all utilities. Miles, 296-5767.

2-BDR. CONDO, 1,000 sq. ft., 2-car garage, enclosed patio, pool, S-pain/Wyoming, \$55,000, financing negotiable. Brandon, 299-3993 or 836-5621.

3-BDR. HOME, Eastridge area, extras, 1,732 sq. ft., \$104,000. Baca, 275-2049.

3-BDR. HOME, 1-car garage, 1-3/4 baths, \$82,500. Gabaldon, 292-7340.

3-BDR. MOBILE HOME, 14' x 80', Four Hills Park, minor repairs needed, \$16,300, take over payments. Huff, 296-3349.

3-BDR. HOME, 1-3/4 baths, completely remodeled, choose your carpet colors, 1 block NE of Indian School & Wyoming, \$84,500. Olson, 294-5663.

2-BDR. MOBILE HOME, 12' x 64', 1-1/2 baths, wood paneling, storm windows, \$6,200. Lujan, 873-0052.

2-BDR. PATIO HOME, 2 baths, landscaping, courtyard, decks, fruit trees, yard has 6-ft. walls, \$93,500. Casidy, 294-5277.

3-BDR. HOME, near Old Town, 2 baths, 2 kitchens, basement, fireplace, yard, \$78,000, consider terms. Montoya, 842-0929.

WANTED

HOUSEMATE, 3 bdrs., 2 baths, swimming pool, quiet neighborhood near Louisiana & Candelaria, close to malls & Sandia, 1/2 utilities, \$300/mo. Semonisck, 883-4212.

AIRBRUSH, prefer dual-action internal mix, will consider others. Rodacy, 293-2668.

REFERENCE MATERIALS, appropriate for high school chemistry class (esp. CRC Handbook and Merck Index). Loehman, 265-3179.

BABYSITTER, for 8-mo.-old & 2-yr.-old children, occasional evenings, preferably located in or near Hoffmantown area. Spinello, 292-5681.

ROCK TUMBLER and polisher, used is OK if in good condition. Ash, 821-7127.

BOY'S BICYCLE, for 7-9 yr. old. Field, 268-0025.

STOCK ALUMINUM VALVE COVERS for a Corvette or Z28 Camaro w/a small-block engine. Bentz, 293-4211.

ALTO SAXOPHONE, in good condition. Schaub, 865-8807.

SKIERS interested in SNL Corporate Cup Ski Team participation this winter, organizational meeting Wed., Sept. 11, 5-7 p.m., Coronado Club, Coronado Rm. Szklarz, 292-3995.

LOST AND FOUND

LOST: Rayban sunglasses, in the last row of the Technology Transfer Center, Aug. 20 noon lecture. Ludwigsen, 4-8581.

SHARE-A-RIDE

BELEN COMMUTER seeks non-smoker carpool or vanpool to Tech Area 1, prefer driver-rotation carpool. Kercheval, 864-6549.



This newspaper can be recycled with Sandia office paper

Coronado Club Activities**Board of Directors Balloting Closes Monday**

EXERCISE YOUR RIGHT to vote in the annual C-Club Board of Directors election during the annual election meeting, Monday, Sept. 9, from 4:30 to 5:30 p.m. After the meeting, votes will be counted and a Mexican-food buffet will be served (free for members; no children, please). Eligible members may also vote from 6 to 8 p.m. tonight (Sept. 6) or 11:30 a.m. to 1 p.m. today or Monday. Any Club member who is a permanent on-roll DOE or Sandia employee (or retiree who was an active member at the time of retirement) is eligible to vote. (Meeting attendees will also be given an opportunity to vote on possible changes in the by-laws concerning the length of time board members can serve.)

TREAT GRANNY AND GRAMPS to brunch. Sunday, Sept. 8, is Grandparents Day, and the

Club gives grandparents a \$1 discount on their meals from 10 a.m. to 1 p.m. Later, "Bob Weiler and Los Gatos" will play at a special tea dance from 1 to 4 p.m. (reservations are required). The other brunch this month takes place Sunday, Sept. 22, from 10 a.m. to 1 p.m. Both brunches are \$6.95 for members, \$7.95 for guests, \$2.50 for children 4 to 12 years old, and free for toddlers.

DIAL UP THE CLUB — The Coronado Club's daily lunch menu and monthly activities schedule are now available on Sandia's Voice Messaging System. Dial the SVMS on 5-6789.

FIESTA, FIESTA — Celebrate "Dieciseis de Septiembre," Mexican Independence Day, on Friday, Sept. 13. The Bourguet Brothers will play from 7 to 11 p.m., and menu items (served from 6 to 9 p.m.) include sizzling fajitas (\$7.95),

cheese enchiladas (\$6.95), chicken breast (\$7.95), prime rib (\$9.95), and golden fried shrimp (\$9.95). Make reservations early.

ATTENTION ARMCHAIR QBs: Monday night means football, and every Monday night beginning Sept. 16 you can enjoy the game on the Club's big-screen TV and two monitors. Munchies, drink specials, and great giveaways also highlight the night.

DINING AND SIGNING — Tuesday, Sept. 17, from 5 to 7 p.m., is the annual Ski Club ski trip sign-up. Sign up for this year's trips, from week-long getaways in Steamboat Springs to extended lesson sessions in Taos. Wine and cheese will be served. Look for the trip agenda to be posted on the bulletin board outside the C-Club.

Events Calendar

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

Sept. 6-8 — "The Holdup," comedy by Marsha Norman about two brothers in New Mexico in 1914; 8 p.m. Fri. & Sat., 6 p.m. Sun.; Vortex Theatre, 247-8600.

Sept. 6-14 — "Passions & Prayers," an evening of short plays by Joe Pintauro, Theatre-in-the-Making presentation; 8 p.m. Fri.-Sat., CenterStage, 260-0331.

Sept. 6-20 — Exhibit, "Impressions of Nature," features the work of F. G. Hochberg, co-founder of the Nature Printing Society and curator of Invertebrate Zoology at the Santa Barbara Museum of Natural History, images printed directly from natural subjects including plants, fish, and shellfish; 9 a.m.-5 p.m. daily, New Mexico Museum of Natural History, 841-8837.

Sept. 6-29 — Exhibit, "The Streets of Mexico: Photographs by Van Deren Coke," photographs taken from 1974 to 1990 capture the social and cultural aspects of street life in older parts of Mexico; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues., 1-4 p.m. Sun.; UNM Art Museum, 277-4001.

Sept. 6-Oct. 4 — Exhibit: "Henry Nadler 1930-1990, A Retrospective"; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues., 1-4 p.m. Sun.; UNM Art Museum, 277-4001.

Sept. 6-Oct. 6 — Exhibit, "Contours of an Unknown Land: Photographs of Clarence John Laughlin 1946-1955"; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues., 1-4 p.m. Sun.; (gallery talk Sept. 17 by Carol McCusker, master's degree candidate in UNM's Department of Art and Art History), Study Gallery, UNM Art Museum, 277-4001.

Sept. 6-Nov. 1 — Exhibit, "Aesthetically Correct/Aesthetically Incorrect," images chart how artistic trends have changed over the last 60 years, copies of manifestos, critical writings, and artists' commentaries accompany each image; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues., closed Mon. & weekends; UNM Jonson Gallery, 277-4967.

Sept. 6-Feb. 9 — Exhibit, "Horse Tales: An Evolutionary Odyssey," produced by the Natural History Museum in a collaborative program with the Hubbard Museum of the Horse in Ruidoso Downs, tells about the horse from its first appearance in North America to its reintroduction by the Spanish to its modern-day place in the natural world; 9 a.m.-5 p.m., New Mexico Museum of Natural History and Science, 841-8837.

Sept. 9 — Monday Lecture Series: "A Cochiti Drum Maker," demonstration and talk by Nate Pecos of Cochiti Pueblo; 10 a.m., Indian Pueblo Cultural Center, 843-7270.

Sept. 12 — Lecture, "Reconstructing the Daily Lives of the Ancient Southwestern Peoples," first lecture in a series of People of the Southwest Lectures, all fall series lectures will focus on the theme "Pre-historic Southwestern Peoples as Seen Through Their Art and Architecture"; 7:30 p.m., Maxwell Museum of Anthropology (UNM), 277-4404.

Sept. 14 — Irish "Hoolie," afternoon of Irish music and song by 10 groups from New Mexico and Colorado, sponsored by the New Mexico Irish-American Society; noon-7 p.m., the Inn at Rio Rancho (1465 Rio Rancho Dr. SE), 281-0814.

Sept. 15-Dec. 1 — Exhibit, "Awards in the Visual Arts 10," 25 works of art by 10 artists from throughout the United States, sponsored by the Southeastern Center for Contemporary Art in Winston-Salem, N.C.; 9 a.m.-5 p.m. Tues.-Sun., Albuquerque Museum of Art, History, and Science, 243-7255.

Sept. 17 & 21 — Lecture and field trip, "The Ethnographic Background of Rock Art at Petroglyph National Monument," Ike Eastvoldt, president of the Friends of the Albuquerque Petroglyphs, presents a slide-lecture about West Mesa rock art in its Pueblo Indian cultural background, foundation for Saturday's field trip to Petroglyph National Monument (two-mile walk on level ground), field trip includes discussion of 40 panels of the petroglyphs in the Rinconada Canyon area of the Monument; lecture 7:30 p.m. Tues., field trip 9 a.m.-12:30 p.m. Sat. (registration required); Maxwell Museum of Anthropology, 277-5963.

Sept. 20-21 — The Marketplace Fall Arts and Crafts Show, works by more than 70 local crafters; 9 a.m.-5 p.m., Wyoming Mall, 294-1606 or 296-0460.

Fun & Games

Boating — The Coast Guard Auxiliary is again offering safety courses in power boating and sailboating. Classes begin Tuesday, Sept. 10, at 7 p.m. at the Armed Forces Reserve Center (400 Wyoming NE). Both courses will be held one evening (Tuesdays) a week for approximately 13 weeks. Classes are free, but \$15 will be charged for a course text for the first family member; additional family members pay only \$5 for work sheets. To register, call Ben Gardiner (ret.) on 298-0116, Earl Livingston on 897-1695, or Bill Hudson on 292-5598.

Basketball — The SERP Men's and Women's Basketball League will meet on the Coronado Club patio Tuesday, Sept. 17, at 4:45 p.m. Teams will have a choice of two leagues; in one, teams play twice a week, Mon.-Fri. evenings at the East Gym; in the other, teams play Saturday mornings at UNM's Johnson Center. Leagues start in November. Deadline for fees and paperwork will be announced at the meeting. Players looking for a team can send their name, phone number, organization, height, and skill level to Steve Nickerson (1201). Teams/players may only play in one league. For SERP information, call Angela Sisneros on 4-8486.



AMUSING WORDS FOR LUNCH — Ken Frazier of Public Information Div. 3161 enjoys a book during a lunch break last week at the Kirtland AFB parade grounds. Ken not only reads 'em, he also writes 'em. He has authored a book about Chaco Canyon and several science books. He's also editor of the *Skeptical Inquirer*, a periodical that uses science to challenge alleged psychic and other paranormal events. And just this week his latest book, an anthology of 43 essays from the *Skeptical Inquirer* by Carl Sagan, Isaac Asimov, Martin Gardner, and other scientists and scholars, was published by Prometheus Books. It's called *The Hundredth Monkey and Other Paradigms of the Paranormal* and examines issues at the intersection of science and popular belief. All that in addition to his public information writing duties for Sandia. (Photo by Randy Montoya, 3162)