

Solar Cell Sets Efficiency Record

Develop a solar cell that's 30-percent efficient. Since 1978, that's been a goal of DOE's solar program. For the past five years, Sandia has pursued this goal as DOE's lead lab in conducting research on high-efficiency crystalline solar cells.

And, as of last month, Photovoltaic Cell Research Div. 6224 reached — in fact, surpassed — the goal. Principal investigator James Gee of that division demonstrated a 31-percent-efficient photovoltaic cell in the division's Photovoltaic Device Measurements Lab.

"Early in our work in photovoltaics, we recognized the importance of improving conversion efficiency," says Don Schueler, manager of Solar Energy Dept. 6220. "We are now seeing the payoff of years of investment in understanding the basics of solar-cell efficiency."

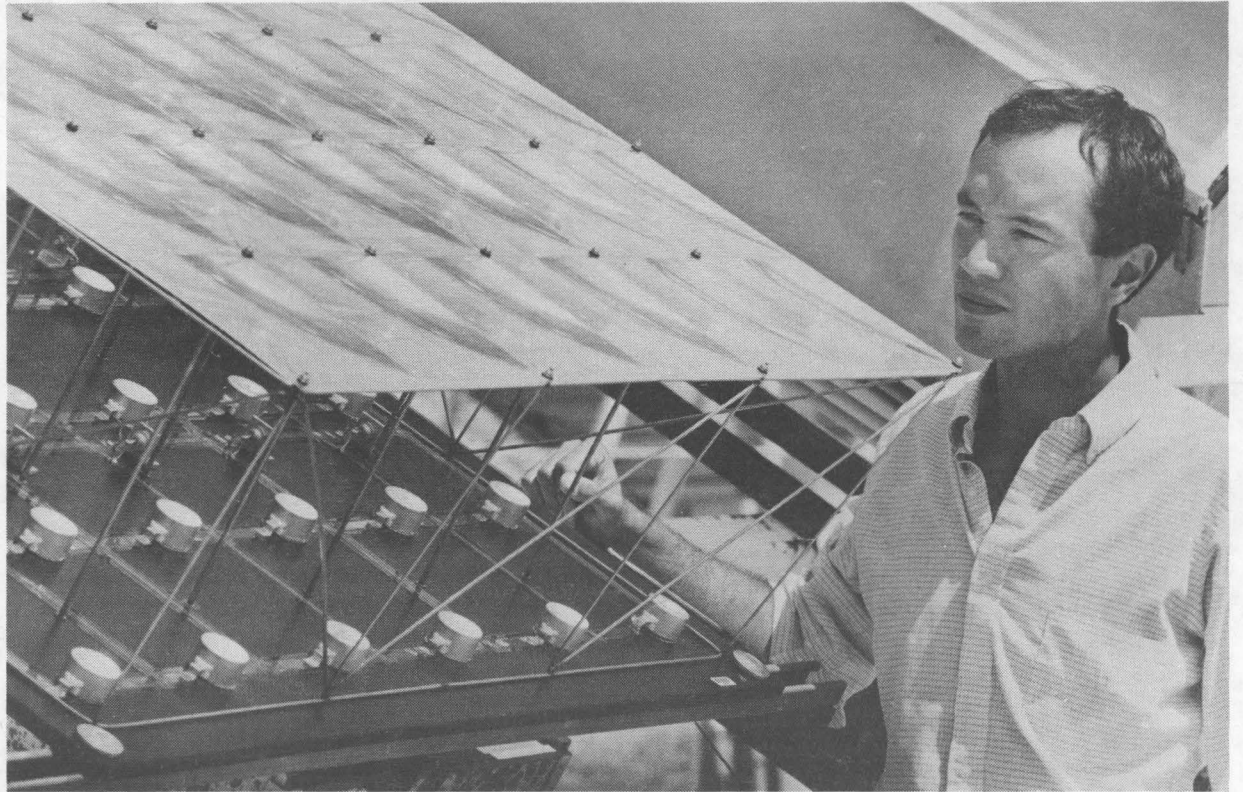
"The achievement is yet another exciting development indicating the rapid progress we've seen in our photovoltaics program in the past two years," adds Dan Arvizu, 6224 supervisor.

The new concentrator cell, which James describes as "a mechanically stacked, multijunction solar cell," is a kind of tiny semiconductor sandwich — a quarter-inch-diam., single-crystal gallium-arsenide cell atop a similar-sized single-crystal silicon cell (see "Solar Cells: Theory and Terminology").

Sandia was involved in the development of both component cells. The gallium-arsenide (GaAs) cell was developed under contract with Sandia by Varian Associates, Inc., of Palo Alto, Calif., and the silicon (Si) cell was developed in cooperation with Stanford University. James used procedures developed over the past four years in assembling and testing the stacked cell.

In brief, light from the high end of the spectrum (the blue end) is absorbed and converted to electricity by the upper cell. Long-wavelength light passes through the GaAs cell to the lower cell, which

(Continued on Page Six)



JAMES GEE'S RECORD-BREAKING SOLAR CELL is not in a working photovoltaic array like this "Varian 1000X" system northeast of Tech Area I — yet. When the time comes, the new 31-percent efficient cell will be placed in a housing similar to the cylindrical cell assembly under his right hand. Above the multijunction cells will be Fresnel lenses like these that will provide solar radiation equivalent to that of 500 to 1000 suns. "That's a greater concentration than the 350 to 500 suns at which the new cell performs at its optimum level, but the greater concentration means greater power output," says Dan Arvizu, 6224 supervisor.



LAB NEWS

VOL. 40, NO. 17 SANDIA NATIONAL LABORATORIES AUGUST 26, 1988

Taking Out Armored Vehicles

Fire Ant Delivers a Lethal Punch

Anyone who's ever experienced a run-in with a fire ant knows the critter delivers a swift and devastating sting to its "target."

A Sandia-developed experimental robotic system named after that fearsome insect operates in much the same way. Designed to spot and destroy moving armored vehicles up to 550 yards away, "Fire Ant" could increase survivability chances for soldiers in

the battlefield, according to James Kelsey, supervisor of Advanced Technology Div. 5267.

"Last summer, we were asked to explore the idea of a system that could take out armored vehicles without endangering soldiers in the field," says James. "In other words, send out an expendable system to do the dirty work while keeping the human operator in a secure location."

Why an expendable system? "A system such as Fire Ant would most likely be used on a conventional battlefield where soldiers are at high risk — and the same would hold true for the system," says James.

Biggest Design Hurdle

"However," James continues, "effective mobile robotic systems require some expensive capabilities: night vision, accurate navigation, and reliable target detection and classification. So our biggest design hurdle was to separate the high-cost items from a less expensive delivery vehicle and munition [warhead] — the part of the system least likely to survive."

Fire Ant fills the bill. A relatively inexpensive four-wheeled ATV (all-terrain vehicle) delivers the munition, while a separate remote control unit (containing costlier components) "directs" the ATV to its attack position.

Using a radio link, the operator positions the vehicle, aims it, sets it to recognize moving vehicles, and arms the munition. Subsequently, Fire Ant fires automatically when a large moving vehicle enters its aim point — for example, an intersection of a road being used by an enemy force. If the situation calls for it, the operator can manually override the

(Continued on Page Five)



JAMES KELSEY (5267), whose division was responsible for overall Fire Ant system integration, displays a mock-up of the mean little critter. Round element at top, an explosively formed penetrator, is Fire Ant's warhead; during field test last fall, it destroyed a surplus tank.

Savings Bond Campaign Results: Page Five

Antojitos

Fire Ant's Entomological and Etymological Antecedent -- As names of Sandia-developed weapons go, Fire Ant's unusual. But it fits the deadly little device (see story on Page One) quite well. First of all, it's tiny in relation to the kind of quarry it's designed to subdue -- armored vehicles, like, say, tanks. Second, it's highly maneuverable and relatively fast. During a field test, it skittered up hills and down looking much like its namesake. And third, it is quite capable of delivering a most memorable sting.

James Kelsey (5267) gets the credit for the apt appellation: "I first thought of the 'queen bee/drone' concept, because it implies the separation between high-value and expendable items we designed into Fire Ant. But that was inappropriate -- bees fly; our system crawls. Then I thought of Fire Ant."

James is a south Texas native, so he had some first-hand (more precisely, first-leg) experiences with fire ants as a kid. "They're fearsome little beasts with a nasty venom," he recalls. "And they leave quite a welt when they bite you."

(Today's lesson: Fire ants, also called thief ants, are illegal immigrants from South America. They're reddish or yellowish ants just one to five millimetres long [less than a quarter-inch] but capable of inflicting a severe sting.)

* * *

CAUTION: WALKING MAY BE HAZARDOUS TO YOUR HEALTH! Walking in Tech Area I, that is. Yes, in principle, "pedestrians always have the right-of-way," but dying to uphold that principle is seldom in your best interest. It is legal for the silent marauders -- bikes and EZ-Go carts -- as well as motor vehicles to travel on those streets. Therefore, if you're striding along the sidewalk in front of Bldg. 838 and suddenly remember you're due at a meeting in Bldg. 836 at that moment, don't veer 90 degrees left and step into H Street without looking. It could be your last veer.

* * *

If You're Seething After Reading the Preceding, rest assured -- no, walk assured -- that Security is on your side. More drivers are being cited for speeding, bikers (especially those who consider Tech Area streets as a worthwhile warm-up for the Tour de France) are no longer considered immune to tickets, and Security is generally clamping down on drivers who forget the "pedestrians are paramount" precept.

One tip: If your vehicle has a motor, drive in first gear inside the Area. Helps you keep from speeding, and helps the walkers hear you. If you're driving a bike or an electric vehicle, make some noise whenever you're passing a pedestrian. Shout, scream, sing, something.

* * *

Expert Testimonial -- And what does automotive expert Pete Witze (DMTS, 8362) of fiber-optic spark plug fame (see last issue) drive? A red and white '66 Ford Fairlane convertible.

* * *

Anyone Ever Seen P O Box 5800? Probably a dumpster. Maybe a railroad car.

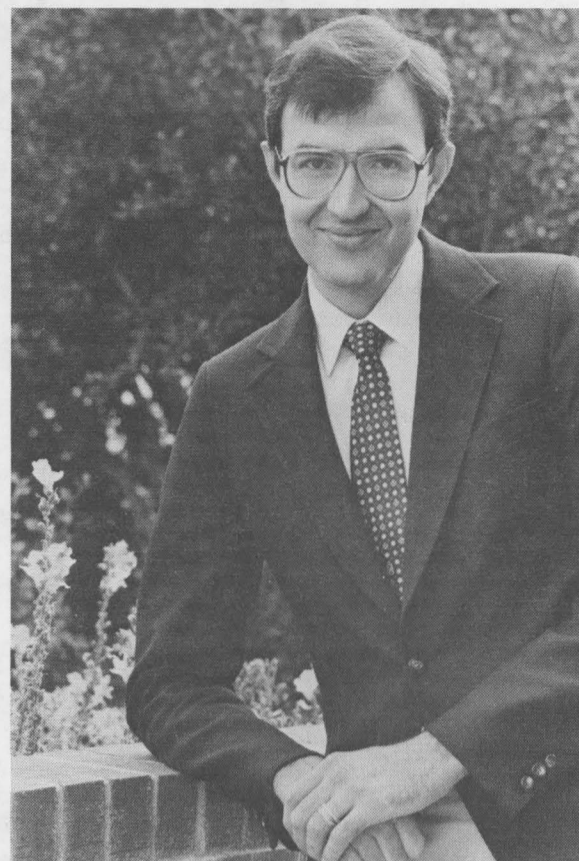
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Don't Forget -- Early deadline next issue: Thursday is Friday. ●BH

* * *

Never attribute to malice that which is adequately explained by stupidity.

Supervisory Appointment



THOMAS BACA to supervisor of Rotational Dynamics Div. 7543, effective July 16.

Tom joined the Engineering Analysis Department's Applied Mechanics Div. IV in June 1976 under the Labs' OYOC (One-Year-On-Campus) program. His work in that division included structural analysis and environments engineering for the Mk 4 and Mk 12A projects.

In 1986, he transferred to the Vibration Testing Division. He was project leader for the Area I and Area III mechanical shock laboratories when he was promoted.

Tom has a BA in Latin American studies and a BS in mechanical engineering, both from Union College in Schenectady, N.Y. He received an MS in mechanical engineering and a PhD in structural engineering (under Sandia's Doctoral Studies Program), both from Stanford.

He is a member of the American Society of Mechanical Engineers (ASME) and the American Institute of Aeronautics and Astronautics (AIAA).

Family activities including camping, cross-country skiing, and model building are Tom's spare-time interests. He's also active in YMCA youth activities.

Tom and his wife Helen have four sons. They live in Northeast Albuquerque.

Spare Your Wastebasket

If you're about to retire or leave the Labs, don't toss your historically valuable records.

Corporate Historian Necah Furman (3141-2) is looking for audiotapes, records, and photos. Call her on 6-9619.

Take Note

Dick Russell, Director of Purchasing 3700, has been elected a Fellow in the National Contract Management Assn. by its Board of Directors. Dick has been active in the contract management field for more than 20 years.

* * *

Margaret Carroll, supervisor of Safety Engineering Div. III 3317, was elected to a two-year term as a Regional Vice-President, part of the national Board of Directors, in the American Society of Safety Engineers.

* * *

Two Sandians were involved in the recent "Structured Development Forum" for software engineers interested in the latest software development techniques. Held in San Francisco and hosted by LLNL,

the international forum attracted 300 people from the public and private sectors. Joe Schofield's (2624) keynote address was on "Emerging Technologies in Software Engineering." Sharon Sardalos (7254) gave a presentation on "Improving Software Quality through Hierarchical Design" and was part of a panel discussion of "Software Quality Assurance."

Out of the Mouths of Nonagenarians . . .

Now that he is 68 years old, you might think that age wouldn't be a joke for former Gov. Terry Sanford, who is seeking a U.S. Senate seat [in North Carolina].

But think again. "I complained to my mother, who's 97 and still driving her own car, that they're trying to make an issue of my age," says the white-haired Democrat, bushy eyebrows bobbing and jowls dimpling. He claims her reply was, "Why son, that's ridiculous -- you're old enough to run."

Wall Street Journal

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SCABBARD Provides Realistic, Large-Scale Battle Scenarios

Sandia's SCABBARD, a one-of-a-kind computer code that simulates military movements and battlefield scenarios, got a real workout recently when a joint US Army/Sandia team used it in support of the Army's Close Combat Capabilities Analysis (C³A).

The SCABBARD work focused on a series of issues related to the hypothetical employment and performance of tactical nuclear weapons in central Europe. The nuclear portion of C³A involves the Army's requirements for tactical nuclear weapons through the late 90s.

The seven-member Army team brought a detailed battlefield scenario to Sandia and worked with Bob Gallagher's Systems Studies Div. 8474 staff in programming it into SCABBARD, a high-resolution, corps-level computer simulation model. Gary Richter served as the Sandia Livermore project leader; Jim Rogers (DMTS) and Tim Tooman (all 8474) also worked with the Army team on a daily basis.

"It's our Cray computer's ability to provide high resolution at the level of an Army corps [tens of thousands of troops and many thousands of combat vehicles], as well as the simulation code itself, that makes SCABBARD unique," says Bob. "The high resolution means that a team can keep track of thousands of individual vehicles, their occupants, and equipment. The tasks the Army asked us to do couldn't be accomplished with any other existing code."

Profitable Exercise for Army and Sandia

Coordinating advanced planning with Gary was US Army Maj. Todd Jones, the Military Research Associate assigned to Phase I & Phase II Studies Div. 8151. Working in parallel with Gary and Todd, Jim and Tim prepared the SCABBARD tools so the most recent set of changes to the computer operating system were available. "This way, the team was able to accomplish substantially more while the Army officers were here than they had anticipated or committed to earlier," says Bob. "It was a profitable exercise for both the Army and Sandia."

Bob says Army groups are interested in SCABBARD for three reasons:

1. It is the only way they can obtain a high-resolution estimate of the movement rates of division-sized units on the battlefield;
2. They are interested in the security of nuclear weapons as they are taken from storage sites to the battlefield, and they wanted to see how these movements would be accomplished when all the combat and support vehicles are competing for the same road network. Simulating this competition would also provide perspective on the vulnerability of the nuclear weapons enroute; and,
3. Meaningful estimates of the effectiveness of tactical nuclear weapons against Warsaw Pact combat units require a realistic treatment of target location errors and movement routes. Because of the high resolution (down to individual combat vehicles) and the use of actual Central European terrain and road information (LAB NEWS, July 17, 1987), SCABBARD is well suited to the task.

"We're only partially finished with the project," Bob continues. "Now that we've worked with the Army team to create the SCABBARD version of the battlefield scenario, our next step is to interpret the results of the recent computer runs. Then there will be further scenario postprocessing and weapon performance assessments."

"We have already learned, however, that some of the movement rates — especially those of the large combat units, or maneuver battalions — obtained from less sophisticated modeling codes appear to be unrealistic. According to Army members of the study team, Sandia's code on the Crays shows that the movement-rate findings were more consistent with real experiences from military exercises."

"We have not simulated any of the nuclear



WORKING WITH THE SCABBARD CODE in Sandia's Remote Processing Center were these Army and Sandia people (from left): Capt. Mark Cawley, Tim Tooman (8474), Capt. Frank Grand, Capt. Emmett Perry, systems analyst Kaye Donovan of the MP School, Maj. Paul Hicks, Maj. Mike Robinson, Jim Rogers (DMTS, 8474), and Capt. Joe Richard.

laydown work yet," Bob notes. "That's the sort of thing that will be important in helping the Army understand the effectiveness of specific weapons. And it will be a part of the study."

More Ahead for Sandia

"It's also the type of activity our division will be doing on a regular basis as a part of ongoing DOE studies," adds Bob. "The most recent example is Gary Richter's contribution to the joint DOE/DoD FOL [Follow-On to Lance] Studies and Analysis Working Group."

Rob Rinne (8470) gets credit for initiating development of the new Cray code in the early 80s; its predecessors include DIVWAG, which ran on CDCs in the mid-70s (LAB NEWS, Dec. 10, 1976). SCABBARD has now been used by Sandia, NATO teams, and the US military on several occasions and in both nuclear and non-nuclear tactical studies.

The Army has permitted Sandia to retain the recent scenario for use in future DOE and DoD studies. "This is significant because this version will most likely be one of the major scenarios used in nuclear studies, as well as in ACM [advanced conventional munitions] areas," says Bob. "And, by being a part of this study, we understand what is behind the

Army's requests for certain performance requirements on weapons. That knowledge puts us in a better position to deal with the Army's needs in the future."

In addition to working the SCABBARD computer code at SNLL, members of the Army team visited SNLA, LLNL, and LANL, the other DOE weapon labs involved in the nuclear portion of the Close Combat Capabilities Analysis.



**SANDIA
LIVERMORE NEWS**

VOL. 40, NO. 17 AUGUST 26, 1988

Congratulations

To Sherry Cruz (8531) and Victor Angelini, married in Manteca, July 3.

Sympathy

To Sandra Brown (8535) on the death of her grandmother in Pasco, Wash., July 14.

To Wayne Chrisman (8347) on the death of his brother in Seattle, Wash., Aug. 3.



EIGHT EMPLOYEES of Sandia's contract security firm, Advance Security Inc. (ASI), came back from the DOE Regional Firearms Tournament July 23 with trophies for excellence in marksmanship (from left in front): Rick Neidner (2nd place in Expert class), Jerry Weber (1st place Expert), Mark Lindstrom (4th place in Tactical Oriented Revolver Stress Course), and Tim Johnson (4th place Shotgun Course); (back row) Bob Allen (1st place Shotgun), Martin Stunkel (2nd place Marksman), Carl Feighner (4th place Action Revolver), and Byron Lee (3rd in Shotgun). There were 60 competitors from around the DOE complex in this region; of the 23 trophies awarded, ASI employees won nine.



MOST OF THIS SUMMER'S 84 YOTs (Youth Opportunity Trainees) — now headed back to school — showed up recently for this photo commemorating the "Class of 88." The only non-YOT shown is program coordinator Soila Brewer (3533; front row,

eighth from right). Soila recruits through teachers in local high schools, colleges, and vocational schools. Teachers screen applicants to pick the most capable and deserving students for summer jobs at Sandia.

Fun & Games

Square Dancing — Swingin' Singles Square Dance Club provides two free square-dance lessons (6:30-8 p.m.) on Sept. 6 and 13 at its headquarters building, located at 4915 Hawkins NE (near San Antonio and I-25). Once your dance-appetite is whetted, you can register on Sept. 20 at 5:30 p.m. (same location) for a follow-up series of lessons. More info from Carolyn King (152) on 294-3125.

* * *

Golf — Sept. 9 is the entry deadline for the annual Hispanic Heritage Golf Tournament, coming up Sept. 12 at Tijeras Arroyo Golf Course (9:30 a.m.). Entry fee of \$35 includes green fee, refreshments on the course, awards, and a golf clinic after the tournament ends. Proceeds go to the Mexican-American Women's National Assn. for its scholarship program. More details from Tom Cordova (3411) on 296-8785.

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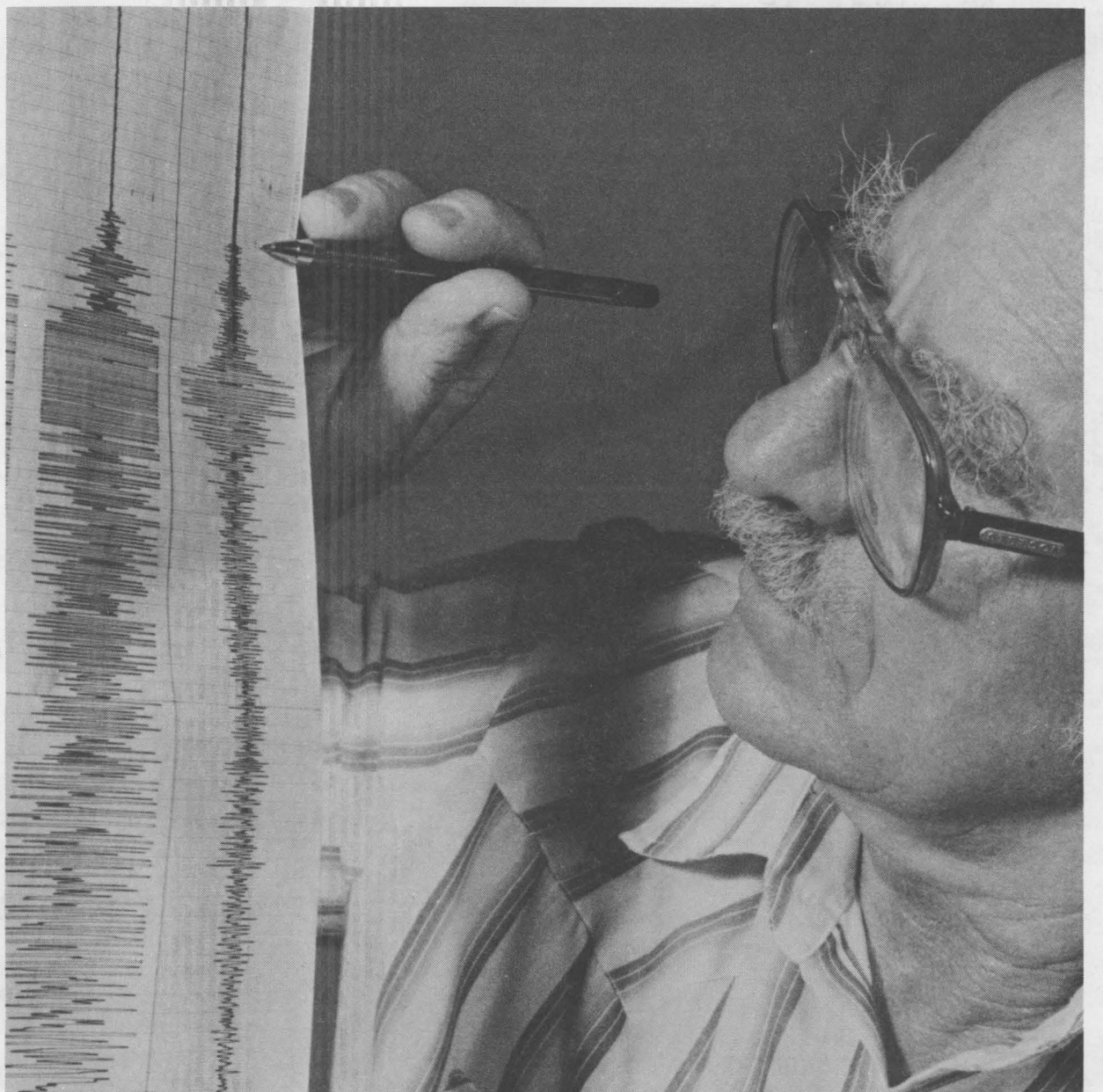
Corporate Cup — Fourteen SNLAans helped AT&T win the national Corporate Cup championship for the second consecutive year. Competing at Stanford University Aug. 6-7 were John Kelly (6454 — team jump, seniors relay); Dave Womble (1422 — team mile); Roger Assink (1812 — 220 sprint relay); Jim Garsow (9216 — 880 submasters distance relay); Jim Schirber (1150 — 660 seniors relay); Tim Wheeler (6412 — 10K, 2-mile executive relay); Kathie Hiebert-Dodd (9115 — 5K, 10K); P.J. McKee (3411 — 5K, 10K); Becky Hunter (9000 — 10K, 1-mile distance medley relay); Mary Walker (1556 — 440 women's relay, 440 submasters distance relay); Larry Walker (9222 — 880 executive relay, 880 submasters sprint relay); Tina Tanaka-Martin (7112 — 440 submasters distance relay, 440 women's relay); Fran Stohl (6212 — 220 masters relay, 5K, 10K); and John Otts (6222 — team shot put). SNLL was also represented; Jim Reitz (8144) participated in the 5K and 10K. Selected for the AT&T team, but unable to participate, were Kay Schoenefeld (6425), Bonnie Vigil (2644), Peggy Walsh (1812) and Joe Trembl (8144).

Bring It Around at 2, Jeeves



Valet parking comes to downtown Cedar Rapids, Iowa, as part of an effort to lure shoppers from suburban shopping malls. For \$2, city employees in fancy uniforms park and retrieve cars as part of a 90-day test program.

Wall Street Journal



SEISMIC RECORD OF HISTORIC SHOT — Jim Durham's (DMTS, 9241) pen is just above some of the seismic traces from the "Kearsarge" underground nuclear detonation at Nevada Test Site on Aug. 17. Part of the unprecedented US-Soviet Joint Verification Experiment designed to determine whether both countries can accurately measure the other's nuclear test yields, "Kearsarge" was the US shot observed by a team of 40 Soviet scientists. In September, a Soviet shot at Semipalatinsk will be observed by a US team; George Patton (9241), Horace Poteet (DMTS, 9115), and Jack Schendel (9112) are among the Americans assisting with preparations for that shot. These seismic traces were recorded at the FACT (Facility for Acceptance, Calibration, and Testing of seismic monitoring systems) site in the remote reaches of the Coyote Canyon Test Complex. Horace was part of the "Kearsarge" team; Carter Broyles (7100) and Paul Stokes (9110) were among the official observers.

Fire Ant

automatic firing system at any time to prevent its operating as programmed.

Sandia equipped the commercially available gasoline-powered ATV with electrically driven actuators for remote control of steering, throttle, brakes, and weapon-platform tilt. A small black-and-white TV camera mounted on the weapon platform sends live pictures to the control unit, whose operator uses a joystick to accelerate, steer, and brake the vehicle.

Computer Processor Takes Over

Once the operator positions Fire Ant and aims the weapon, a computer processor in the remote control unit takes over. Using the transmitted TV image to determine target motion in the camera's field of view, the processor arms the munition when it senses moving vehicles; Fire Ant is then ready to fire when a vehicle reaches the exact aim point.

A high-explosive charge propels — at speeds greater than 6600 feet per second — a 22-pound copper slug, which can zero in on targets nearly a third of a mile away. Before it's fired, the explosively formed penetrator (see "High-Speed Cannonball") sits atop the Fire Ant delivery vehicle, giving it the appearance — true to its name — of a large, one-eyed insect. Unlike most antiarmor weapons, the munition is self-contained, with no need for a guiding barrel.

The munition's speed, according to James, accounts for part of its accuracy. "Unlike duck hunting, where the hunter aims at a point ahead of the flying bird," says James, "the Fire Ant projectile's rapid-fire delivery makes 'leading' the target unnecessary." Other details of the guidance system are classified, he says.

The munition's compact design (15-inch diameter) allows Fire Ant to remain maneuverable — even in tight spaces — and makes detection by an enemy soldier or sensing device more difficult. Including the mounted munition, Fire Ant is about four feet tall and long and two feet wide.

Design and development of the Fire Ant demonstration system moved along rapidly, according to project leaders Bill Caskey (5267) and Steve Roehrig (5249). "Only two months elapsed between the time we began design work and the first live-fire demon-

High-Speed Cannonball

Explosively Formed Penetrators Provide Stand-Off Capability

One of the few Fire Ant components that's not an off-the-shelf item is its warhead. The compact (15-in.-diam.) munition, called an explosively formed penetrator (EFP), consists of a detonator and high-explosive charge inside a steel case behind a concave copper faceplate.

As the device "sees" a target move across its aim point, the explosive charge detonates, causing shock waves to strike the copper lens in front. The lens, propelled forward by the force

of the explosion, in effect collapses in on itself, deforming into an oval-shaped slug as it moves forward toward the target at a high rate of speed. In effect, the 22-lb. copper slug becomes a high-speed cannonball.

EFPs are not new; similar, smaller devices have been developed by the Army to provide a stand-off anti-armor capability. But Fire Ant's EFP is the largest ever built. That has advantages in both speed and distance.

stration last September," Bill says. "That first field test — in Coyote Canyon — showed that we were on track in terms of concept."

"Fire Ant hit and destroyed a rebuilt, surplus M-47 tank that we'd rigged with a camera and actuators to control its steering and brake/throttle functions," adds Steve. "And — as we expected — Fire Ant was also destroyed by the force of the munition as it fired."

Though Labs developers believe the system proves the concept, James says the military — at this point — has made no decision about building or using Fire Ants. "In the meantime," says James, "we're working on larger systems that place high-value items — things like infrared imagers, inertial navigation systems, and computer processors — in a survivable, reusable package."

Queen Ants and King Ants

One such system, described by James as the "Queen Ant" concept, includes a larger unmanned, teleoperated vehicle that could lead, carry, or tow four to ten Fire Ants into a battle zone. Another is a fixed-location command base ("King Ant") with specialized electronics for controlling many more Fire Ants.

Lowering Fire Ant's center of gravity to ensure its stability while traveling over rough terrain is a design focus for future models. One design approach,

James says, would be to install a system that would stow the warhead inside the ATV as it travels toward its destination, then raise the projectile above the vehicle once it stops.

"Fire Ant appears to be cost-effective," notes James. "If a delivery vehicle and its munition costing several thousand dollars can be used to destroy an armored vehicle costing perhaps a million, it's obviously an excellent military investment."

Fire Ants could possibly be used for other kinds of missions as well, James points out. For example, they could be used to spot and designate targets, cover troop withdrawals, occupy high-risk positions, and gather route intelligence.

Several Labs organizations contributed to the Fire Ant effort. "It was truly a team effort in every sense," says James. His division was responsible for work on the teleoperated-vehicle concept and for overall system integration. Ed Hoover (9133) coordinated work on the video motion detection system, while Bob Nellums (9122) was project coordinator for munition (warhead) design. Track and Cables Div. 7535, with Tom Stueber as test director, coordinated the live-fire demonstration last fall.

Contractor assistance came from EG&G, which built various pieces of hardware, and from the New Mexico Energy Research Institute, which modified the tank target for the field test.

●PW/LPerrine (3161)

Welcome

Albuquerque

- Sabine Boruff (7865)
- Christopher Henderson (2142)
- Mark Howard (2853)
- Allen Sault (6212)
- Eric Thulin (2857)

California

- Kathleen Erickson (2625)

Colorado

- Keith Bauer (2621)
- Eric Klamerus (6447)

Connecticut

- Michael Hinckley (7556)

South Dakota

- Francis Hansen (6313)

New York

- Joel Wendt (1141)

Occupational Disease No. 72



At a recent gathering of molecular biologists, Feedback spotted what looked like a genuine case of "Gilson's thumb." Apocryphal among gene splicers, the affliction is a sort of tennis elbow for scientists. It gets its name from a piece of apparatus, . . . a thumb-operated automatic pipette often known in the trade as a Gilson.

Cloning or sequencing DNA means hours of sweated labor over a hot Gilson. Sadly, the inflamed tendons of this particular genetic engineer met with little sympathy from his colleagues. "Just needs to oil the Gilson," one of them muttered.

New Scientist

9 Directorates Hit 100%

Savings Bond Allotment Edges Toward \$3 Million Level

Most money experts and nearly all Sandia employees share at least one point of view: They believe investing in US Savings Bonds is a smart financial move.

That fact's confirmed by the final results from last spring's Bond drive. This year, Sandians will invest an all-time high — \$2,936,949 in Bonds. The record allotment is an 8.7 percent increase from a year ago, according to Jack Tischhauser (2850), 1988 Savings Bond chairman.

"Once again, the Bond effort received tremendous support from employees at all locations — Albuquerque, Livermore, Tonopah, and Pantex," says Jack. "It's obvious that Sandians recognize a good deal when they see one — and Bonds are certainly that."

A 'Right to Be Proud'

Final 1988 Bond drive stats show that 96.56 percent of Sandians now buy Bonds, a 3.77 increase in participation from the beginning of the campaign. "That participation level is second only to the record high of 96.7 percent established in 1985," Jack notes. "Historically,

Sandia has had an outstanding participation record, and employees have every right to be proud."

Nine directorates (up from five last year) achieved 100 percent participation: 200, 400, 1200, 1400, 2700, 2900, 6300, 6500, and 7200. Members of the "Almost-100 Club" (98 percent or better) are 100, 1100, 1500, 2100, 2500, 2800, 5200, 6200, 7100, 7500, 9100, and 9200. Honorable mention for 97+ percent participation goes to 1800, 2300, 5100, and 8200.

The total Bond allotment translates to an average \$29.55 per month per employee, compared to \$27.27 a year ago. About 46.5 percent of Labs employees are at or above the Bond-a-month level, up from 45 percent last year.

"Our outstanding campaign results didn't just happen," says Jack. "They reflect a lot of hard work, enthusiasm, and time on the part of members of the Savings Bond Committee, as well as VP and directorate reps.

"I'd like to express my thanks and gratitude to each one of them — and to the many Sandians who recognize 'the Bond advantage.'" ●PW

(Continued from Page One)

Solar Cell

operates in the red portion of the solar spectrum.

Alone, the Varian cell achieved an efficiency of 27.2 percent. James tested several bottom cells, with peak efficiencies for the stacked cell ranging from 29.5 to 31 percent at the simulated intensity of 350 to 500 suns (1 sun = 1 kW/m²).

The Stanford-developed cell had the highest bottom cell efficiency, 3.8 percent. "That appears low," says James, "but efficiency is defined in terms of the total light incident on the cell stack. Only about half the light reaches the bottom cell."

Highest-Ever Conversion Efficiency

According to James, the new composite cell represents the highest-ever photovoltaic conversion efficiency (the fraction of the solar radiation hitting a solar cell that's converted into electricity). It's the first time that a multijunction cell has clearly exceeded the performance of the best single-junction cell. The previous record for a multijunction cell was 26.6 percent, also achieved with a GaAs/Si cell assembled and tested at Sandia two years ago.

"Much of the solar community was skeptical about our chances of breaking the 30-percent goal this year," says James. "But we had excellent support from our cell developers, Varian and Stanford."

"The 30-percent efficiency level turned out to be as much a psychological barrier as a technical one," adds Virg Dugan, Director of Advanced Energy Technology 6200. "I've been comparing it to the four-minute mile — just as many runners were able to break that barrier once Roger Bannister did it in 1954, I expect other research groups will achieve

Second Milestone This Year

The solar-cell success story is the second this year for Dan Arvizu's Photovoltaic Cell Research Div. 6224.

The previous milestone in DOE's five-year research plan was the demonstration of a >24-percent, mounted, single-junction silicon cell that could easily be wired into a module (the housing containing optics and an array of cells). The division surpassed that milestone in May with two separate cells, a 24-percent-efficient cell

fabricated by the University of New South Wales (Australia) and a 25-percent cell fabricated by Stanford University.

Sandia's photovoltaic-cell research project consists of an in-house research effort, including unique laboratories for device measurements and fabrication, and a complementary university/industry contract research program that has proven highly productive.

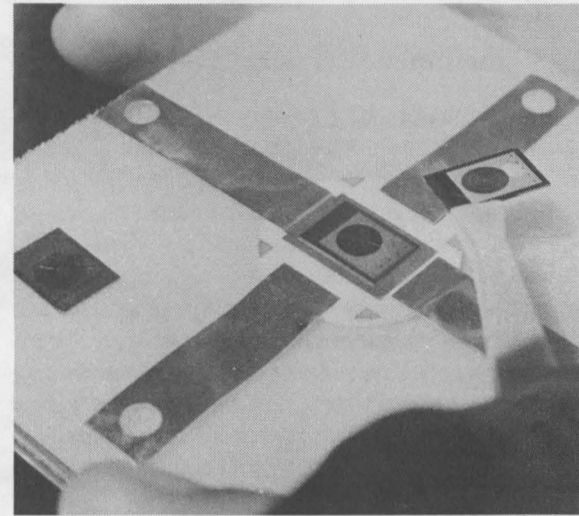
30-percent efficiency, at least in a lab setting, very soon."

Although the new cell has so far been tested only in the simulated solar spectrum of a laboratory, it's slated to become a "module-ready device" capable of producing nearly 8 watts of electrical power in a field-test environment.

Eventually, the module-ready devices will be incorporated into a concentrator module, consisting of a series of sunlight concentrators (Fresnel lenses) and cell assemblies built into the module's housing. Modules can then be connected in an array to produce a meaningful amount of power. Concentrator development is a task of Photovoltaic Technology Div. 6221, headed by Eldon Boes.

Ahead, Cheaper Power

The next step in DOE's photovoltaic research plan is to group the cells and install them in a module that's 25-percent efficient. (Module efficiencies will be less than those of the cell because of losses in the electrical and optical parts of the module.) DOE's plan also calls for pushing experimental cell efficiencies to 35 percent. "That probably means perfecting a bottom cell that's 5- to 6-percent efficient,"



DISASSEMBLED ASSEMBLY — At the intersection of the leads is the silicon cell; in the tweezers is the gallium-arsenide cell that will be stacked on the other one. The result is a solar cell that achieved a 31-percent efficiency in Div. 6224's Photovoltaic Device Measurements Lab.

says James. "Combining that with a gallium-arsenide top cell in the 29- to 30-percent range would allow us to reach the 35-percent goal."

Although photovoltaic systems are not considered economically competitive with fossil-fueled or nuclear power plants for utility power today, photovoltaic systems are becoming common in areas of the globe not served by traditional electrical distribution systems, such as small islands or areas in the Third World.

"And that's with systems having cell efficiencies less than 20 percent," says Eldon. "If a new cell increases that efficiency significantly, at modest increase in cost, photovoltaics will become more attractive for conventional electricity markets, including utility-grid applications."

Photovoltaics are already the power source of choice for many space applications. The new cell could be qualified for space "in a couple of years," says James.

James was assisted by Misch Lehrer (EG&G) in assembling and testing the new cell. Clement Chiang (6221) and Dave King (6224) played key roles in the development of the cell's predecessors.

●BH/WKeener(3161)

Solar Cells: Theory and Terminology

A solar cell, also called a photovoltaic cell, is a solid-state device that converts solar radiation directly to electricity. The key word is "directly." In contrast to solar cells (which use the sun's light), solar-thermal technologies use the sun's heat to boil water, molten salts, or other liquids, and convert that energy to electrical power via conventional turbines.

Although the photovoltaic effect was first observed in 1839, it wasn't until 1954 that the first real photovoltaic cell was developed. That cell, which grew out of Bell Labs' pioneering work in semiconductors (the same work that led to the transistor) was about four percent efficient.

A solar cell is essentially a semiconductor with a built-in electrical field. This field is created by joining (that is, creating a junction between) materials that have different electrical properties.

When a photon (light is made up of photons of different energies) is absorbed in the semiconductor, an electron becomes a charge carrier. That is, the electron is activated to a state in which it's mobile. The mobile charge carriers are collected by the built-in electric field, producing the flow of current that powers a load.

The optical response of a semiconductor is determined by its "bandgap" (its light-acceptance characteristics). Photons with energy less than the bandgap are not absorbed. Photons with energy equal to or greater than the bandgap can be absorbed and activate electrons (although any energy that exceeds the bandgap is dissipated as heat in the semiconductor).

Unfortunately (at least for photovoltaic applications), sunlight has a broad spectral range — 0.3 to 4 microns in wavelength. Therefore, even in theory, the maximum efficiency achievable (when known material limitations are considered) in a single-junction, single-bandgap cell is only about 31 percent in unconcentrated sunlight.

A multi-bandgap, multijunction solar cell has a higher maximum achievable efficiency

because it divides the broad solar spectrum into smaller portions to which each junction is better matched. For example, a two-junction cell has a maximum theoretical efficiency of about 42 percent in unconcentrated sunlight.

Multijunction = Multi-Spectral

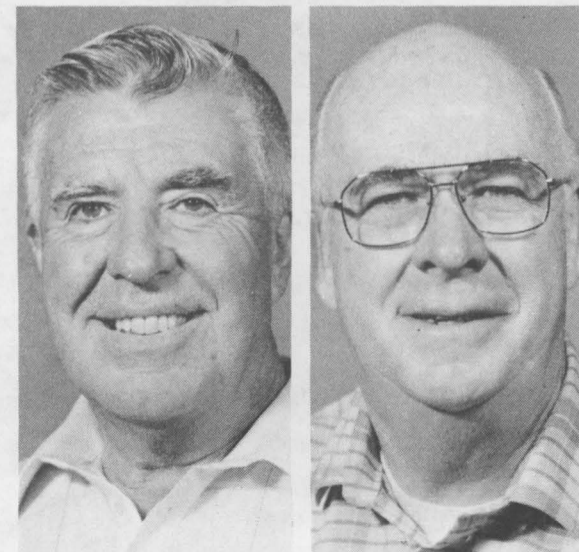
Multijunction cells are sometimes referred to as "multi-spectral" because of the way they work. In the stacked GaAs/Si cell, the GaAs cell converts the portion of the solar spectrum below 0.87 microns, and the Si cell converts the portion between 0.87 and 1.2 microns. "So the maximum achievable efficiency improves with the number of junctions," says James Gee (6224), "although the complexity of the cell soon becomes overwhelming."

Creating a multijunction cell involves one of two approaches. The approach taken by Sandia is to fabricate the component cells separately, and then to mechanically stack the component cells by means of a transparent adhesive. This approach allows use of well-developed single-junction cell technologies — GaAs and Si.

The second approach is a monolithic cell; that is, grow the junctions on a single substrate. The monolithic approach is conceptually simpler, and it avoids the cost of additional substrates and cell processing. The Solar Energy Research Institute in Golden, Colo. (the other DOE-sponsored photovoltaic laboratory) develops and supports monolithic multijunction solar cells. However, the formation of the complex, thin layers necessary to create semiconductors with appropriate bandgaps in sequence has proceeded slowly because of some very difficult materials issues.

Sandia's recent success has now caused several groups to seriously consider mechanically stacked, multijunction cells for applications such as space power that were not considered feasible a few years ago.

Retiring



Dean Yearout (2361) 37 Ralph Brown (DMTS, 2362) 30

Have an Itch for Italian (Food)? Indulge It Instantly — Tonight

WHEN THE MOON HITS YOUR EYE like a big pizza pie, that's amoré — and it also means it's Italian Night on the patio this evening. Enjoy a bountiful buffet featuring the likes of lasagna (meat or vegetable), spaghetti with meatballs, stuffed pasta shells, veal or egg plant parmigiana, and manicotti. Bring the family; kids under 12 get a smaller portion for \$1.50. Sounds Unlimited provides the dance music from 5 to 9 p.m. And remember — if you'd rather be wet than wild, C-Club members swim free on Friday nights until 9.

PEOPLE ARE POLITICKING for seven slots to be filled on the C-Club Board. (Why not? Lots of folks are running for election this year.) Winning vote-getters will be announced at the annual meeting on Sept. 12 from 5 to 6 p.m. on the patio. Vote on weekdays, Sept. 6 through Sept. 12, at the Club from 11:30 a.m. to 1 p.m. (also 6-8 on Friday, Sept. 9) — or cast your ballot from 4:30 to 6 at the annual meeting. Free refreshments after the meeting while votes are being tallied. Current board members seeking reelection are Anna Bachicha (DOE), Alice Maese (133), and Jack Mortley (7521). Other nominees are Charlie Kaspar (ret.), Carolyn Lange (123), Ruben Muniz (143), John Otts (6222), and Mike Quinlan (7833).

OLD COWHANDS FROM THE RIO GRANDE — and young ones too — cook their own steak (T-bone or New York cut) next Friday night (Sept. 2) at Western Night. Other menu choices include BBQ brisket and chicken, or fried fish. The band with the noteworthy name, Trio Grande, plays shuffle music under the stars from 7 to 11 p.m.

DON'T LABOR ON LABOR DAY — Instead, come out to the pool/patio area on Monday, Sept. 5, for a "Goodbye-to-Summer" party that'll scorch your

sandals. Festivities start at 11 a.m. and continue until 6. A BBQ buffet, featuring the finest of holiday picnic fare, is served from noon until 5. The patio bar serves up 50-cent beer and your other favorite libations, while Sounds Unlimited puts out the happy music from 2 until closing. Fun and games all day long, with a lot of prizes to boot. As usual, for this last big blast of the season, members are admitted free; guests pay \$2.50.

SEPTEMBER SWIMMING — You can still enjoy a cool dip in the Club pools on Friday evenings (4-8 p.m.) and Saturdays and Sundays (11 a.m.-5 p.m.) throughout the month of September. (Finally, we've rid ourselves of the belief that Labor Day automatically means a complete pool shutdown!) Official close date this season is Sept. 30.

A GROUP OF WELL-KNOWN ALLEY CATS, aka the C-Club Mixed Bowling League, is looking for more round-ballers to fill slots on a couple of four-person teams. The fall season begins next Wednesday (Aug. 31) at Sandia Bowl (Lexington & Juan Tabo NE). If you're interested in joining the strikes-'n-spare set, call Sharon Noblitt on 255-6113.

A GOOD DEAL is what you get when you join the Thunderbird card sharks for fun and games; the wheeler-dealers get together for September sessions on the 8th and 22nd. Action starts at 10 a.m., and includes a variety of card games, plus free refreshments and door prizes — not to mention a lot of good conversation.

THE BEAT GOES ON — the bingo beat, that is. Players go for big prizes at patio bingo nights next month on Sept. 8 and 22. Card sales start at 5:30 p.m. Soup and sandwiches available at low cost, and the early-bird game kicks off at 6:45.

Take Note

As part of KAFB's celebration of this year's Hispanic Heritage Week, a Hispanic Organizations Seminar is set for Sept. 20 from 8 to 10 a.m. in the East Theater. Members of IMAGE, GI Forum, MANA, and LULAC will present the rationale, history, goals, and objectives of each organization. For more information on the seminar or other Heritage Week events, call Pete Casaus, KAFB's Hispanic Employment Program Manager, on 4-2909.

* * *

This evening at 5, the Sandians Club is holding a "Get-Acquainted Pot Luck" dinner in the west part of the Coronado Club patio. The Sandians, a women's social club, is open to all female employees and the wives of Sandia employees and associated contractors and consulting firms. For more information on tonight's dinner or the club in general, call Karen Ruby at 299-0767.

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Teddy bears to teen crises, fatherhood fears to "professional moms" and single parents — and more. Parentcraft, an information and support program offered to parents by the Division of Family and Children's Services, Inc., has a new catalog describing nearly 100 courses for families with children of all ages. Call 243-2611 for a copy of the catalog and further information.

Retirement Seminars

Steven Stubbs and Michael DeVincentis of Dean Witter Reynolds will present a seminar, "Planning for Your Retirement," on Aug. 31 at 5 p.m. at the DWR office, 6400 Uptown Blvd. NE. Topics include IRA rollovers and Dean Witter's new retirement planning tool, PRIME (Pre-retirement Income Management Evaluator). RSVP to Steven or Michael on 883-0123.

Fred Lancaster of New York Life Insurance Co. presents another seminar on retirement planning on Aug. 31 at 5:15 p.m. at City Center (6400 Uptown Blvd. NE), Suite 590 West. If you plan to attend the session, call Fred on 883-5757.

Events Calendar

Aug. 26 — Zoo Music: New Shtetl Band, Eastern European klezmer music; 7:30 p.m., Rio Grande Zoo, 848-1370.
 Aug. 26-28 — "Santa Fe Sunshine," adult comedy by Preston Jones, examination of local New Mexico art scene and its colorful characters; 8 p.m. Fri.-Sat., 6 p.m. Sun.; Vortex Theatre, 247-8600.
 Aug. 26-28 — Bubonicon 20, NM's only science fiction/fantasy convention; masquerade, auctions, speeches, movies, art show, readings, book signings; 5-10 p.m. Fri., 8 a.m.-midnight Sat., 8 a.m.-noon Sun.; Clarion Four Seasons, 256-7161.
 Aug. 26-31 — Ehecattl Aztec Dancers, "flyers" soar down and around 80-foot pole; 7 p.m. weekdays, 6 & 8 p.m. weekends & Labor Day; Indian Pueblo Cultural Center, 843-7270.
 Aug. 26-Sept. 10 — "Three Plays Full," Theatre-in-the-Making (education program of New Mexico Repertory Theatre) presents three one-act plays: "Strawberry Envy" by Kitty Johnson, "Out at Sea" by Vladmir Mrzoczek, and "In Fireworks Lie Secret Codes" by John Guare; 8 p.m. Fri. & Sat., Rep East (3211 Central NE), 260-0331.
 Aug. 26-Sept. 18 — Exhibit, "Garó Z. Antreasian, A Retrospective"; 9 a.m.-4 p.m. Tues.-Fri., 5-9 p.m. Tues., 1-4 p.m. Sun. (reception and gallery talk by artist, Aug. 23, 5:30 p.m.); UNM Art Museum, 277-4001.
 Aug. 26-Sept. 21 — "Dinosaurs in Action," exhibit of four mechanical dinosaurs: adult and juvenile triceratops, brontosaurus, and tyrannosaurus; 9 a.m.-5 p.m., NM Museum of Natural History, 841-8837.

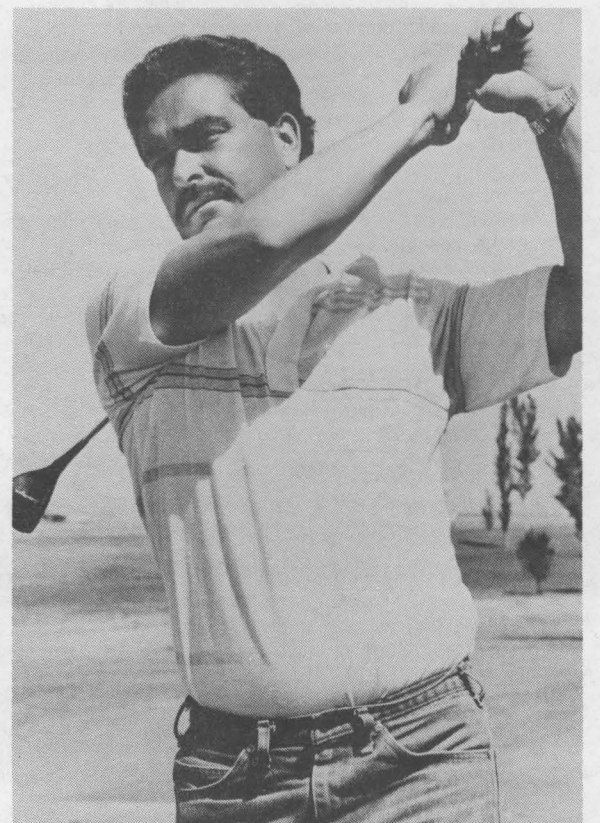
Aug. 26-Oct. 10 — "Spectacular Vernacular," traditional desert architecture of West Africa and Southwest Asia, exhibit circulated by the Smithsonian Institution Traveling Exhibition Service; 9 a.m.-4 p.m. Mon.-Fri., 10 a.m.-4 p.m. Sat.; Maxwell Museum of Anthropology, 277-4404.
 Aug. 27-28 — Fiesta Artistica: food, entertainment, arts & crafts; 10 a.m.-10 p.m., Civic Plaza and Convention Center, 768-3490.
 Aug. 28 — Zoo Music: Albuquerque Municipal Band; 2 p.m., Rio Grande Zoo, 848-1370.
 Aug. 28 — Arts in the Parks: Big River Boys, Robbie Weinstein, Flights of Fancy, Village Dancers, and Red Hot Peppers; 2-4 p.m., Ridgcrest Park (Carlisle & Ridgcrest SE), free, 764-3490.
 Sept. 9 — June Music Festival Benefit Concert: violinist Leonard Felberg and pianist Arlette Felberg performing works by Brahms, Beethoven, Fauré, Bartók, and de Falla-Kochanski; 8:15 p.m., Keller Hall (UNM), 881-0844.

Flush with Money

After a hard day at the office, more working couples are rushing home to the bathroom. Not just any bathroom — a hedonistic "high-end" bathroom with features like marble walls, stereos, VCRs, and dual whirlpool tubs. [Interior designer] Doris Bachmann of Hackensack, N.J., who specializes in sumptuous spas, charges anywhere from \$25,000 to \$95,000 for her creations. Luci Globus, a consultant to American Standard Inc. who keeps an eye on market trends, finds all this ironic. "The bathroom was the most Victorian room in the house," she says, "and now it's becoming the sybaritic center, the place where people go to pamper themselves."

Stephen MacDonald, Wall Street Journal

Retiring and not shown in LAB NEWS photos: Louie Armijo (7412), Francis Thompson (9223), William Walker (DMTS, 7526), Robert Roberts (7242), Robert Sowell (1834), and Vincent Hansen (5231).



JIM SALAS (2512) WASN'T CHASING BALDYS when he scored a rare double eagle on Hole 12 at the Tijeras Arroyo Golf Course on July 6. Jim used a number 3 wood twice to accomplish this 100-times-rare-as-a-hole-in-one feat. A double eagle is a score of three under par for a hole.