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# SANDIA REPORT

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## Sandia National Laboratories and Higher Education in New Mexico

R. R. Fairbanks

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## **Sandia National Laboratories and Higher Education in New Mexico**

Sandia National Laboratories  
Albuquerque, NM 87185

### **Abstract**

Sandia National Laboratories interacts extensively with colleges and universities in New Mexico. This report briefly covers these relationships in employee education, research contracts, loaned equipment, and other areas.

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## **Sandia National Laboratories and Higher Education in New Mexico**

### **President's Perspective**

The theme at Sandia's recent observance of our 40th anniversary was "exceptional service in the national interest." Sandia has attempted over the last 40 years to extend that sense of contribution and cooperation to our state and local educational institutions. Our record in working with New Mexico schools, colleges, and universities indicates that we have succeeded.

However, we live in times when significant change will be common. As educational institutions change to meet the needs of the nation, the Sandia commitment to supporting education at all levels will change and expand. I am personally committed to the concept that we, as a laboratory, will actively promote and enhance broad educational goals as one of our missions.

This booklet enumerates current programs and levels of support Sandia provides to education in Albuquerque and New Mexico. Additional efforts will be forthcoming as expanded needs are identified and Sandia continues to contribute to educational quality in New Mexico.

AL NARATH  
President

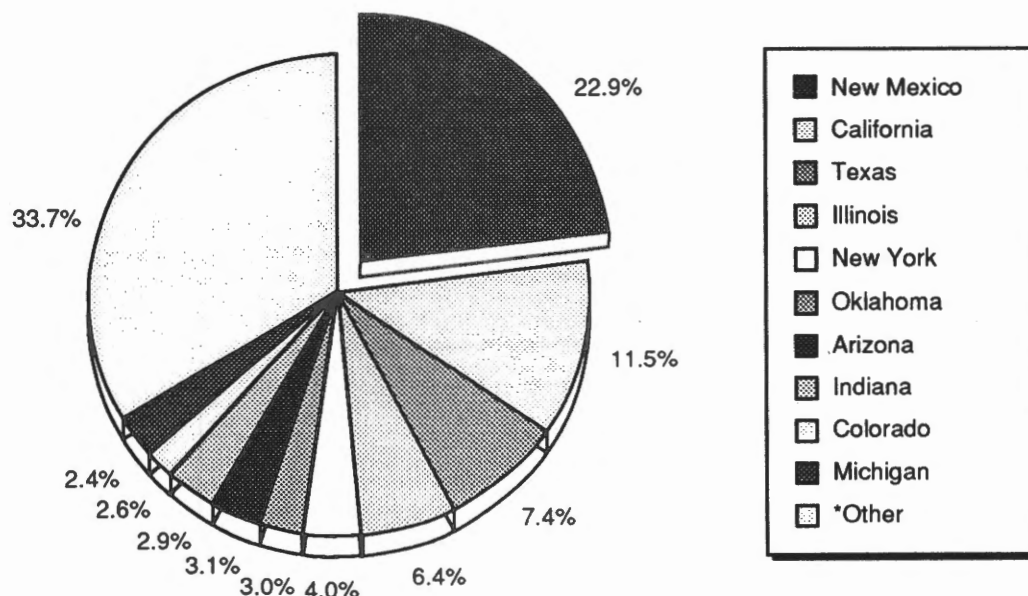
## **New Mexico Higher Education's Impact on Sandia**

New Mexico educational institutions have had an extraordinary influence on the Sandia workforce throughout the years. Today, our approximately 8400 employees hold 2028 graduate and undergraduate degrees from the 4-year colleges and universities in the state. This accounts for 22.3% of the degrees held by Sandia employees. Employees also hold another 618 2-year degrees from New Mexico educational institutions. The total number of degrees is nearly twice the number from the next leading state, California (Figure 1). When only the highest degree held by an employee is considered, that degree (PhD, master, or bachelor's) came from a New Mexico college or university 29% of the time (Figure 2). Employees whose highest degree is from the University of New Mexico (UNM) rank, in numbers, at the top of most categories of management and staff at Sandia Albuquerque (Figure 3).

UNM, with its proximity to our headquarters in Albuquerque, has granted the most degrees to Sandia employees. Employees also hold degrees from New Mexico State University (NMSU), New Mexico Institute of Mining Technology (NMIMT), and from other 4-year regional institutions in the state. Engineering degrees and degrees in business are the most numerous, although employees hold degrees in many other fields, reflecting the diversity of work being done at the Laboratories by graduates of colleges and universities in the state (Figure 4). For more detailed information, refer to Appendix A.

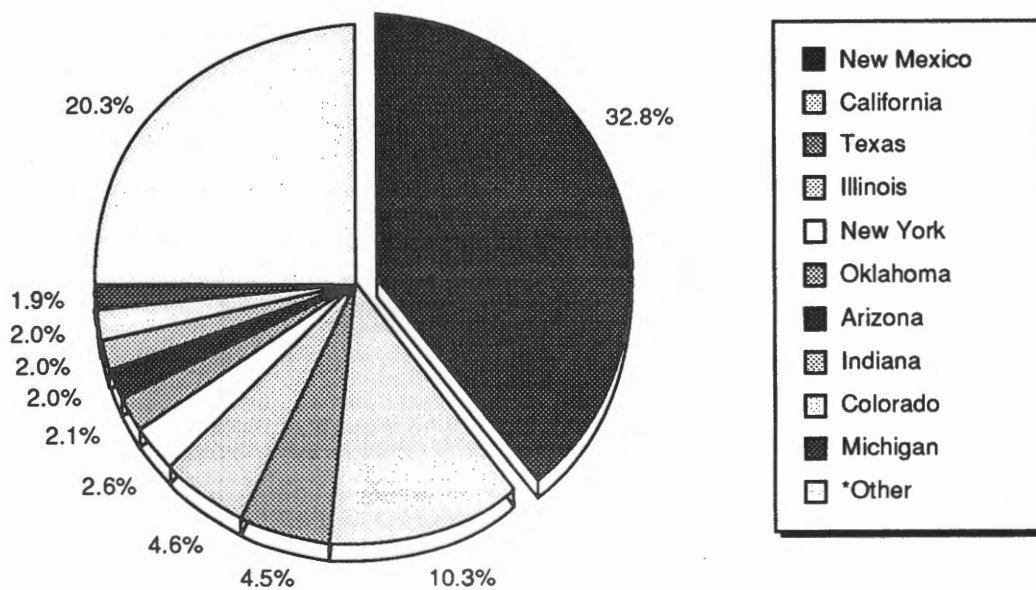
### **Education of Sandia Employees at New Mexico Institutions**

Sandia-sponsored education of employees, the first formal relationship we had with colleges and universities in New Mexico, remains an elemental part of that relationship today. At least 400 employees take classes at (or receive instruction from) a college or university in the state at any one time at Sandia expense. In addition, we pay the expenses of about 75 employees attending the Technical-Vocational Institute in Albuquerque. Instructional television (ITV) courses, taught at Sandia by UNM, NMSU, and NMIMT instructors, have become an increasingly important part of employee education in recent years. Payments to New Mexico educational institutions for employee education total about \$380,000 annually.



\*Includes all other states and countries

**Figure 1. Degrees at Sandia National Laboratories by State**



\*Includes all other states and countries

**Figure 2. High-Degree Counts by State for Regular On-Roll Employees**

## **Educational Assistance Program**

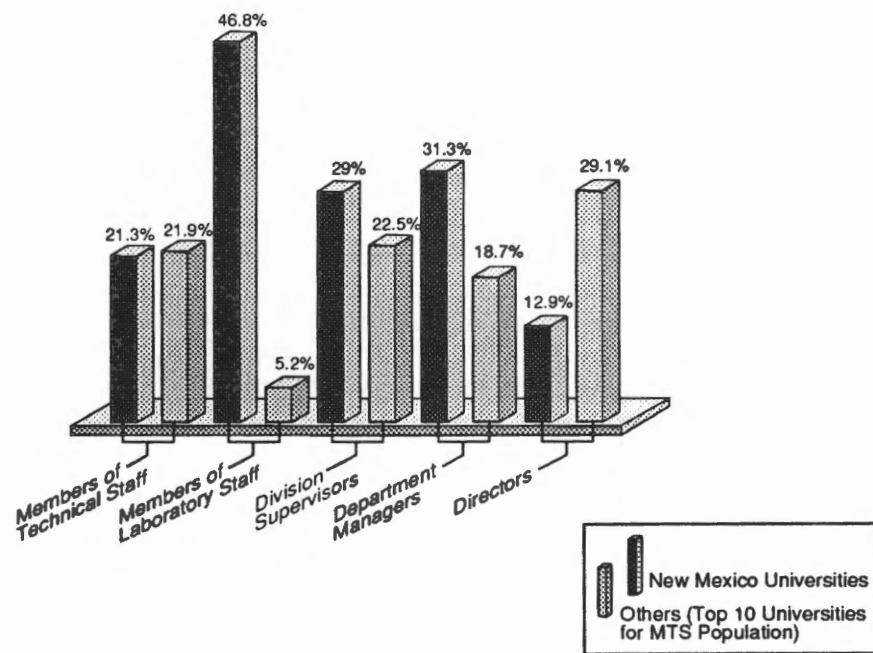
The Educational Assistance Program (EAP), begun in 1956 at UNM, is the forerunner of all Sandia-sponsored employee education. Today, about 350 students each semester attend classes taught by personnel from UNM and the College of Santa Fe (at its Kirtland Air Force Base branch). This total includes employees enrolled in ITV classes broadcast from UNM.

Although about half the employees in the EAP take classes only during the evenings, eligible employees may take up to 7 1/2 hours a week to attend classes at UNM. All College of Santa Fe classes, which lead to a bachelor's degree in business administration or a master's degree in business administration (MBA), are taught after-hours. Courses taken at UNM are diverse, including engineering, physics, mathematics, chemistry, geology, computer sciences, and several others. About 80% of all students in the EAP are seeking a degree, and slightly more than 50% are graduate students.

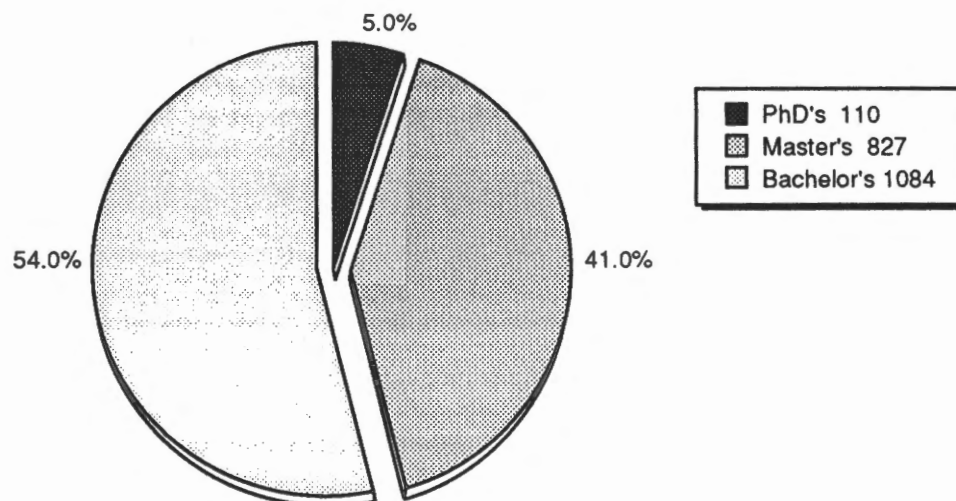
The EAP is a program of mutual benefit, providing the educational institutions with a steady stream of capable students while enabling Sandia to help on-roll employees advance in their careers. Our expenses for tuition and other EAP expenses totaled about \$200,000 in fiscal year 88-\$120,000 at UNM and \$80,000 at the College of Santa Fe. For fiscal year 89, these expenses totaled about \$240,000-\$130,000 at UNM and \$110,000 at the College of Santa Fe.

## **In-Hours Technical Education Courses**

UNM instructors also teach In-Hours Technical Education Courses (INTEC) at Sandia. INTEC is a noncredit, on-premises educational program consisting of both ITV and live lecture classes. In the current academic year (1989-1990), 14 of the 67 live lecture classes are taught by UNM professors, and 75 of the 80 ITV courses originate from UNM. (The others are received either by satellite from the National Technological University, a consortium of 21 universities headquartered in Fort Collins, Colorado or by microwave from NMIMT.) ITV enrollment for the academic year totals 445 employees, 216 of whom are degree-seeking EAP students. Sandia pays a surcharge for each student in the UNM-originated classes to cover the cost of the broadcast. The estimated charge for the 1989-1990 academic year for all students is \$113,000.



**Figure 3. High Degrees for Sandia Albuquerque Management and Staff as of January 11, 1990**



**Figure 4. Degrees From New Mexico Colleges and Universities**

## **Graduate Education Programs**

Sandia sponsors three employee education programs that impact the graduate schools at the state's three research institutions (UNM, NMSU, NMIMT): One-Year-On-Campus (OYOC), University Part-Time (UPT), and the Doctoral Study Program (DSP). The DSP permits members of Sandia's technical staff to attend engineering schools at selected universities around the nation, including UNM and NMSU. The UPT program permits employees to work at Sandia while pursuing a master's or PhD in engineering or computer science at UNM. We have 19 students in this program at present. Sandia pays tuition and other fees, plus a grant of \$2000 for each student. We pay the same expenses and grants for the OYOC program participants, who are minority bachelor-level employees pursuing a master's degree primarily in engineering and computer science. Candidates for this program are selectively recruited from several campuses, including the New Mexico research universities. There are typically about 20 participants in the program. The current group includes five from UNM and three from NMSU.

A fourth program, the Specialized Engineering Development (SED) program, provides UNM with about 15 graduate students per semester. Implemented in the fall of 1985, the SED program is designed to assist qualified new hires in obtaining master's degrees in a field of specialized need. Fields of study include computer science, electrical engineering, and mechanical engineering.

## **Interaction with the Technical-Vocational Institute**

The Laboratories have a continuing relationship with the Technical-Vocational Institute (T-VI) in Albuquerque. About 75 employees attend T-VI each semester, taking courses that are job-related or related to jobs that employees aspire to, or both. Classes are held in the evening. Sandia pays all expenses, which total about \$16,000 annually, and we support T-VI with about \$140,000 in loaned equipment. Sandia also cooperates with T-VI and the Albuquerque Public Schools Career Enrichment Center in a program that enables students to work and take classes at Sandia in their third and final trimester after completing the first two trimesters at T-VI or the Center. More than 100 students have graduated from this program since it began in 1974.

## **Educational Outreach Efforts**

Sandia is in the process of expanding its programs that primarily serve the needs of the educational community, including students, faculty, and institutions themselves. While some of these efforts are national in scope, most primarily serve the New Mexico community. In fiscal year 1989, there were six such programs. Table 1 summarizes the programs.

### **Hand-On, Minds-On Technology**

This program, targeted to the needs of African-American pre-college students in the Albuquerque area, just completed its third year. It reaches about 70 students each year. Serving mostly middle school students, this afterschool program is six weeks in duration, three evenings each week. It covers a variety of topics, including computer science, physics, and electronics. Fifteen members of Sandia's staff volunteer their time to teach. Sandia provides the material necessary for the classes, and the Albuquerque Public Schools provide the Career Enrichment Center as the facility for the program. Sandia spends about \$15,000 on this program.

### **Summer Science Program**

In cooperation with the Albuquerque Public Schools and the Bernalillo Public Schools, this Sandia program completed its 15th year in July, 1989. Sixty students attend all-morning classes for four weeks, studying physics, materials science, mathematics, computer science, and electronics. The students receive 1/2 academic units of credit for participating in this program, which includes a final comprehensive exam. Sandia staff develop and teach the courses, Sandia provides all necessary materials, and the two school districts (along with UNM this year) provide the classroom space at their high schools offering summer sessions. The 1989 expenditures on this program were about \$25,000. Nearly 30 staff members are involved in the development and teaching of the program.

### **Minority Engineering Program (MEP) at UNM**

In the summer of 1989, Sandia entered into a contract with the College of Engineering at UNM to develop a model minority engineering program that would address the needs of Hispanic and Native American engineering students while including all minority engineering students. In its early stages, this contract is planned for two years at a cost of \$60,000 per year.

### **New Mexico MESA**

As a founding member of New Mexico's Mathematics, Engineering, and Science Achievement Program (MESA), Sandia continues to support this program through equipment loans valued at about \$10,000, in-kind services of about \$5,000, and active membership on the Board of Directors. MESA supports the pursuit of achievement in mathematics and science by middle school and high school students through after-school tutoring, weekend activities, award programs for excellence and participation, and a year-end recognition banquet for students, parents, teachers, and corporate sponsors.

### **The Summer Teacher Enrichment Program**

STEP began nearly a decade ago through the efforts of US Senator Pete Domenici. STEP provides an opportunity for middle school and high school teachers to upgrade their knowledge

and skills through practical work experience in area related to their educational specialties and through exposure to Sandia's programs and projects. Teachers work during the summers in a laboratory environment in their own discipline and are involved directly in research with Sandia scientists and engineers. In 1989, eleven teachers participated in the twelve-week program at a cost of \$75,000.

### **Science and Technology Alliance**

As the lead Laboratory in the Department of Energy's Science and Technology Alliance, Sandia has played an important role with all three of the universities involved (two of which are outside New Mexico) but especially at New Mexico Highlands University: here is where Sandia is supporting the development of an accredited Engineering Technology Program. Sandia's participation in 1989 included: \$415,000 of loaned equipment, \$46,000 in summer employment of NMHU students and faculty, \$29,000 to support the developing technical library, \$30,000 for the purchase of various necessary materials, and the loan of two staff who are serving as faculty members, plus \$5,000 for their living expenses. The other participating DOE labs are Los Alamos National Laboratory and Oak Ridge National Laboratories. The other universities are North Carolina A & T University and the Ana G. Mendez Education Foundation. The purpose of the alliance is to increase the representation of African-American, Hispanic, and Native American scientists and engineers in the U.S. workforce by strengthening three large minority institutions of higher education.

**Table 1. Summary of Educational Outreach Programs—FY89**

<b>Program</b>	<b>Budget</b>	<b>Equipment</b>	<b>Sandia Staff Participating</b>
Hands-On, Minds On Technology	\$15,000	0	15
Summer Science Program	\$25,000	0	30
MEP at UNM	\$60,000	0	0
NM MESA	\$5,000	\$10,000	2
STEP	\$75,000	0	10
Science & Technology Alliance-NMHU	\$110,000	\$415,000	2
Total	\$290,000	\$425,000	59 (5 1/3 FTEs)

### **Sandia Contributions to Instruction**

Sandia supports several activities, such as adjunct professorships at UNM, that contribute directly to the instruction of students at colleges and universities in New Mexico. In addition, Sandia is using its expertise in instructional television (ITV) to explore the further use of this promising teaching technique throughout the state.

## **Adjunct Professors**

Twenty-five members of our staff, primarily from technical organizations, are teaching at UNM as adjunct professors. They are the reciprocals of the 25 UNM professors who teach, mostly by means of ITV, in our EAP and INTEC programs. Sandians teach in the College of Engineering and the Anderson School of Business. Teaching loads typically include about three college-credit hours a week in such courses as thermodynamics, nuclear reactor kinetics, mechanical vibration, and management. Occasionally, members of the Sandia technical staff also provide instruction on Sandia premises for UNM students.

## **Instructional Television**

Sandia has developed a state-of-the-art capability in instructional television (ITV) for educating its own employees and is playing a lead role in determining if this technique can be more widely used in New Mexico. We initiated a joint ITV working group in 1985 that is coordinating the exchange of ITV information in the state, reviewing ITV problems in other states, and identifying possible problems in New Mexico. The group reported findings to the State Commission on Higher Education. The group also developed a statewide ITV plan at the request of the Legislative University Studies Group. Besides Sandia, the working group includes several public and private entities; UNM, NMSU, NMIMT, Los Alamos National Laboratory, Kirtland Air Force Base, White Sands Missile Range, Holoman Air Force Base, BDM Corporation, Honeywell-Sperry Defense Systems, US West, Public Service of New Mexico, Riotech, and Technet.

Sandia facilitated installation of the ITV system at UNM, providing technical aid, equipment, and seed money—\$100,000 in fiscal year 86 to employ 24 instructors for the INTEC/EAP programs. Sandia continues to fund instructors through tuition and the ITV surcharge and, in fiscal year 88, provided \$37,000 in equipment. We also assisted NMSU and NMIMT with their ITV systems: we participated in the NMSU market survey and helped establish the ITV link at the university by means of the Technet fiberoptics network.

Sandia is a member of the Distance Learning Alliance of New Mexico. The Alliance is a statewide group of organizations involved in distance learning. Other members include Los Alamos National Laboratory, UNM, NMSU, ENMU, TVI, Luna Vocational, APS, BDM, Honeywell, and the State Bar Association. The purpose of the Alliance is to share instructional resources and information related to distance learning. Distance learning includes any educational setting where the teacher and student are apart. It involves two-way interaction as well as independent activities by the student, and it involves technologies like instructional TV, computer networks, and teleconferencing.

Sandia expects to deliver courses soon from our Laboratories not only to UNM, but also to NMSU and NMIMT by means of the Technet network. ITV courses for these latter two universities have been used in Sandia's on-premises classes. Explosives technology courses from NMIMT are now offered at Sandia. Sandia is collaborating with UNM on the Manufacturing Engineering Curriculum, which is a joint degree program between UNM and NMSU. We foresee that the three research universities will ultimately offer joint degrees in other technical fields by providing instruction via ITV in areas where each excels.

## **Other Educational Programs and Interactions**

Sandia supports various advisory efforts and interactions that promote education and instruction in New Mexico. Many activities are centered in our Education and Training Department, which provides five or six employees (full-time equivalents) whose principal responsibility is support of—and interactions with—higher education in New Mexico and other states. In addition to ITV and the specific college and university programs detailed previously, these activities include representation by Sandia personnel on several advisory boards and committees, including the

- UNM/Sandia Joint Education Working Group
- Board of Directors of the School of Management Foundation at UNM
- New Mexico Vocation Education Council
- New Mexico Consortium for Research and Development in Occupational Education at UNM
- Mathematics, Engineering, and Science Achievement (MESA) Program Board of Directors at UNM
- State Commission on Higher Education
- Albuquerque Public Schools Career Enrichment Center Advisory Committee
- Albuquerque Technical-Vocational Institute Advisory Committee
- New Mexico Industrial Technology Advisory Council
- Academy for Educational Leadership
- New Mexico Apprenticeship Coordinators' Association

Sandians assist with a variety of university programs and proposals at UNM and NMSU:

- A graduate degree program in telemetry at NMSU, where we helped design and develop the curriculum and provided other support such as hiring two NMSU students for the One-Year-On-Campus program.
- A ceramics research center proposal to the National Science Foundation. Developed jointly by UNM, Los Alamos, and Sandia, this proposal would provide for a center that includes graduate-level training in ceramics sciences.
- The Center for High Technology Materials at UNM. Sandia personnel have assisted with proposals to Sematech, the US consortium on semiconductor manufacturing, on metrology and analyses for on-line process control.
- Nuclear Research and Education Committee at UNM. Sandia assisted with curriculum design and development and provided career counseling for both students and faculty.

## **Contracts for Research and Other Services**

Sandia relies on colleges and universities in New Mexico for a variety of services, including research. Contract awards for these services have increased 36% since fiscal year 87. In fiscal year 87, the dollar amount of contracts awarded totaled \$4,028,000; \$3,154,000 of that amount went to UNM. In fiscal year 88, awards totaled \$4,771,000 and in fiscal year 89 they increased to \$5,496,000.

Awards for independent research by faculty and graduate students constitute a substantial portion of these contracts. Such work is conducted across a range of technical and scientific disciplines. At UNM, for example, research is presently under way in biology, chemistry, geology, mathematics and statistics, meteoritics, physics and astronomy, engineering (electrical, mechanical, civil, chemical, nuclear, computer), and several other fields. The quest may be for knowledge that will be used to solve a specific technical problem in one of our defense or energy programs (high-power switching studies for Sandia's Particle Beam Fusion Accelerator, for example) or for information with no specific application, such as that obtained under a Sandia University Research Program (SURP) contract.

Such Sandia-sponsored research is often at the forefront of modern science and technology. For instance, a UNM professor working with our Intelligent Machine divisions on robotics has developed software algorithms for a computer program that controls a three-finger hand. This hand, powered by 12 separate motors, is believed to be the most advanced hand of its kind. It might ultimately be used for such tasks as picking up items from a hazardous area—the bottom of a nuclear reactor pool, for example. Also in Sandia robotics research, UNM personnel are investigating force feedback control of mechanical grippers and how computers communicate with each other in robot control.

Sandia manages a DOE contract for technical services with the Southwest Technology Development Institute at NMSU for operating and collecting data from photovoltaic arrays at a test facility in Las Cruces. Nontechnical services are also secured. For example, we contract with the UNM library for interlibrary loan services to obtain copies of technical journal articles not available at Sandia. This contract typically has an annual value of about \$70,000.

**Table 2. Activity With Educational Institutions in New Mexico  
for FY88-89**

Institution	Contract Awards		
	FY87	FY88	FY89
University of New Mexico	\$3,154,000	\$3,764,000	\$4,479,000
New Mexico State University	569,000	312,000	362,000
New Mexico Solar Energy Institute (NMSU)	138,000	408,000	*0
New Mexico Institute of Mining & Technology	92,000	257,000	518,000
College of Sante Fe	60,000	1,000	123,000
Albuquerque Technical Vocational Institute	5,000	12,000	**0
Webster University	10,000	17,000	14,000
Total	\$4,028,000	\$4,771,000	\$5,496,000

\* Amount is zero because contract is no longer funded by Sandia; work continues with direct DOE funding.

\*\* Zero amount indicates that fiscal year 88 contract extended into fiscal year 89. Fiscal year 90 award projected to be \$16,000.

### **Sandia University Research Program**

The core of the Sandia research effort at New Mexico universities through the years has been the Sandia University Research Program (SURP). SURP dates back to 1957 when we began supporting research projects at UNM; the program expanded in 1985 to include the State's two other research institutions, NMSU and NMIMT.

SURP is basically a faculty development program in which promising new faculty members are granted a research contract. It is limited to faculty members who have been on the staff of one of the three universities 2 years or less. The contracts are "seed grants"—usually the first grant money the investigator has received. The research is conducted on campus and the project is limited to 2 years, and is funded \$30,000 each year. The grant is just large enough to fund research by a graduate student, pay the summer salary of the faculty member, and lessen his or her teaching load during the academic year.

While SURP projects are primarily for faculty development and not to solve an immediate Sandia technical problem, an important aspect is that each project director (candidate) must find a technical sponsor at Sandia to work with or to whom the research will be of interest. Once a project is selected after extensive committee reviews at both Sandia and the university, the candidates submit quarterly reports and a final report on their work. Through the years, SURP funding has proved to be a critical first step in helping faculty members build successful research programs. Once the SURP contract is complete, the investigator is often able to obtain additional grant money from other industrial or governmental sources, frequently in much larger amounts than the original SURP grant. Sometimes the university has maintained collaborations with Sandia technical organizations long after the SURP funding has ceased.

In fiscal year 88, we supported 16 projects—nine at UNM, four at NMIMT, and three at NMSU—at a total cost of \$480,000 (Table 3.) In fiscal year 89, we supported 18 projects—11 SURP projects at UNM, three at NMIMT and four at NMSU—at a total cost of \$540,000 (Table 4).

**Table 3. Sandia's University Research Program, FY88**

<b>University</b>	<b>Research Area</b>	<b>Project</b>
NMSU	Chemistry	Investigation of coherent forward scattering spectroscopy for the determination of refractory metals at trace concentrations
	Mechanical engineering	Adaptive multilevel solution of large elliptic systems on vectorized computers—Phase II
	Mechanical engineering	Pseudoinverse control of redundant robot manipulations in real time
NMIMT	Chemistry	Thermal response of certain mononuclear explosives
	Geophysical research	Measurement of direct lightning strikes
	Materials/metallurgical engineering	High-temperature bonding of silicon carbide
	Explosive technology research	Shock-induced chemical synthesis of intermetallic compounds
UNM	Chemistry	Immobilization of metal clusters and complexes in zeolites
	Civil engineering	Force identification from structural responses
	Electrical engineering	Nonlinear lasers and laser arrays
	Geology	Correlation of organic-inorganic diagenesis in sandstones intercalated with organic-rich sediments: Piceance Creek Basin, Northwestern Colorado
		The formation and evolution of deformation microstructures
	Mathematics/Statistics	Mathematical study of a multi-phase flow model for the combustion of gas-permeable reactive granular material
	Physics	A proposal to study the evolution of spiral galaxies
		Coherent transport of trapped resonant excitations

**Table 4. Sandia's University Research Program, FY89**

<b>University</b>	<b>Research Area</b>	<b>Project</b>
NMSU	Chemistry	Interferometric whole-field deformation sensing underground
	Mechanical engineering	On parallel computation of network optimization problems
		Parametric analysis of parachute unsteady aerodynamics
	Electrical engineering	Three-dimensional modeling of electromagnetic field coupling complex cavities
NMIMT	Metallurgical engineering	Micromechanisms of deformation and fracture of Ti-Al-No alloys
		Electrical conduction in high-resistance ceramics
	Computer science	Random pattern testability analysis of VLSI circuits
UNM	Chemistry	Molecular routes to structural ceramics via specifically designed inorganic polymers
		Construction and characterization of self-assembled monomolecular recognition systems
		Fabrication of nanometer structures by scanning tunneling microscopy/lithography
	Statistics	Numerical simulation of suspensions
	Mechanical engineering	Accumulative material damage induced by microcracking: thermal & mechanical interactions
		Fabrication of ceramic/ceramic composites
	Civil engineering	Characterization of fracture and healing in rocks
	Micro engineering ceramics	Fabrication of thick composite films by simultaneous aerosol and chemical vapor deposition
	Computer science	Efficient manipulation and storage of geometric data

## **Part-Time UNM Faculty**

Sandia has joined with UNM and Los Alamos National Laboratory in a partnership program that creates a new class of three-year faculty appointments for top scientists from the two Laboratories. This program encourages the Laboratories to do joint research and to exchange personnel, services, and equipment with universities. The program is an example of the cooperative programs developed through the UNM-Sandia Joint Working Group.

Most appointments will be made in mathematics, the physical sciences, and engineering. Scholars and researchers appointed to the new positions will teach one three-credit course a year at UNM and will be given full departmental rights. Sandia professors will spend five to six days a month on campus during teaching semesters and one to two days during nonteaching semesters. The increased presence of Sandia on the UNM campus will help Sandia in recruiting and provide more dissertation topics. The program is expected to provide UNM with additional top-quality faculty without having to conduct formal searches for high-caliber scientists.

## **Research With Product Potential**

A significant aspect of Sandia-sponsored research is the potential for development of products or processes that may impact the New Mexico economy. A current example is work on the downhole seismic source, a tool that could help energy companies to better exploit oil and gas reservoirs. The tool is simply lowered into deep drill holes, where it transmits sound waves into the surrounding rock. Underground features—fluid-filled rock, for instance,—alter these waves in known ways so that when they reach receiving antennas in other drill holes, a picture of the ground between the holes results. Besides its ability to provide an improved picture of potential hydrocarbon-bearing strata, the new tool could be adapted to assess the stability of coal mines and dams. This tool grew out of several years of work and field testing conducted by Sandia and co-inventor Dr. Richard Hills, an engineering professor at NMSU. Santerra Corporation, one of the newest New Mexico companies owing its existence to Sandia technology transfer, was recently formed to commercialize the downhole seismic source.

Energy companies could benefit from yet another recent cooperative effort in which Sandia joined with NMIMT and Los Alamos National Laboratory in the New Mexico Improved Oil Recovery Project. This project is run by the Petroleum Recovery Research Center at NMIMT. Funding for the center is provided by both the state and private industry. The goal of the project is to develop and validate advanced methods of reservoir characterization for oil recovery processes through interdisciplinary and multi-institutional efforts focused at a field laboratory. The field laboratory is a small petroleum reservoir donated to NMIMT. Located near Hobbs, it is available to both universities and industry to conduct research. It is expected that the project's research will result in, among other valuable contributions, improved oil recovery processes.

SCB Technologies, Inc., is a New Mexico start-up company formed to commercialize a device developed jointly by Sandia, the Technology Innovations Center, and Center for High Technology Materials, both at UNM, and NMIMT's Center for Explosives Technology Research. The device, about the size of the capital "C" on the tails side of a penny, is called a semiconductor bridge (SCB). Developers envision many commercial and military uses for this tiny device that ignites small explosive charges in only a few millionths of a second, about 100 times faster than conventional "hot wires." The SCB seems a natural for mining industry applications since it delivers precisely timed but separate explosions and can be operated to ensure that physically separated groups of explosives ignite simultaneously. These timing considerations can affect such safety-related issues as structural soundness of mine tunnel

arches and the efficient rubbleization of large rocks. The SCB also may be an attractive way to trigger automobile air bags.

Two efforts that could ultimately lead to commercial developments are under way between Sandia and researchers in the UNM School of Medicine. In one project, a miniature radiation sensor is being developed jointly by personnel in Sandia's Microsensor Division and UNM's Cancer Center. The goal of the cooperative project is an implantable dosimeter that can give an instant, precise measurement of the dose rate and total dose received by a cancer patient. A method has been developed for mounting the sensor (a radiation-sensing field-effect transistor, or RADFET) inside a standard medical catheter commonly used to implant radioactive pellets in patients to treat certain types of cancer. The device has been tested at both Sandia and UNM, and plans are underway to license the device to a commercial manufacturer.

In another collaborative project involving researchers in Sandia's Chemistry Instrumentation Research Division and medical school personnel, a glucose sensor is being developed to accurately measure the glucose concentration in whole blood using infrared spectroscopy. The goal is to develop a non-invasive glucose monitor.

Sandia is also collaborating with UNM, Los Alamos National Laboratory and NMIMT in the UNM Center for Micro-Engineered Ceramics. The combined research strengths of the four institutions is increasing the visibility and reputation of New Mexico with the ceramics industry and increasing technical opportunities for New Mexico businesses.

A special short course is being developed for New Mexico industry through a contract between Sandia and UNM. Entitled "Design for Manufacturability," a similar course was developed at Sandia for design engineers and for DOE contractor personnel. Dr. Joe H. Mullins, Director of the Manufacturing Engineering program at UNM, assisted in the design of the Sandia course. The purpose of the course is to improve an engineer's ability to produce designs that meet customer performance requirements and are manufacturable, maintainable, reliable and cost-effective.

And finally, Sandia played a key role in the development of the Manuel Lujan, Jr. Space Tele-Engineering Program at NMSU. Dedicated in December 1989, the program administers the Center for Space Telemetry and Telecommunications Systems (CSTTS) and the Advanced Telemetry Processing Pilot Program (ATP<sup>3</sup>). Sandia, NASA, the Jet Propulsion Laboratory, and others have been working with NMSU since 1987 to develop a Center of Excellence in the area of telemetry systems both in its academic and research programs. Already, NASA has provided over \$1.5 million in funding to the CSTTS and ATP<sup>3</sup>.

## **Grants and Loans of Equipment and Material**

Each year Sandia grants or loans property and material to universities in New Mexico for research and other educational purposes (Table 5). Grants, awarded under the Department of Energy's Energy-Related Laboratory Equipment (ERLE) program, consist of outright gifts of used equipment such as oscilloscopes, voltmeters, and power supplies. The items are for use in energy-oriented educational programs, with emphasis on the life, physical, and environmental sciences and on engineering. Loans include spare or unused laboratory equipment that is required at one of the universities for immediate use on a Sandia research project or for some other application at the institution.

**Table 5. Grants and Loans of Property and Material to Universities and Colleges**

<b>University</b>	<b>Grants of Equipment (\$)</b>		<b>Loans of Property and Material (\$)</b>	
	<b>FY88</b>	<b>FY89</b>	<b>FY88</b>	<b>FY89</b>
UNM	2,923	0	1,869,194	1,147,437
NMSU	19,819	0	107,796	149,433
NMIMT	0	0	191,115	159,862
TVI	216,016	0	0	142,772
NMHU	0	0	0	415,495
Total	238,758	0	2,168,105	2,014,999
Total US	461,267	1,119,151	8,094,553	7,611,098

## **Temporary Employment of Students and Faculty**

Temporary employment of faculty members and students, including those from high schools, is an important facet of Sandia's support of education in New Mexico. Often this employment involves special programs (Table 6) tailored specifically to the employee's career interests while, at the same time, the employee obtains on-the-job experience and funds to finance further education. Temporary employment also allows Sandia to become thoroughly acquainted with outstanding students who may be candidates for full-time employment later. Student and faculty employment also enhances our reputation with educational institutions, making it easier to recruit outstanding employees.

**Table 6. Temporary Employment, FY89**

<b>Program</b>	<b>Number of Participants</b>	
	<b>New Mexico</b>	<b>Other States</b>
Career Exploration	11	0
Faculty Sabbatical	2	3
Graduate Business Intern	1	0
Graduate Engineering Intern	5	1
Student Intern	4	0
NMSU Summer Drafting	2	0
Outstanding Student Summer Program	8	53
Secretarial Skills Building	0	0
Summer Teacher Enrichment Program	11	0
Undergraduate Engineering Co-op	4	1
University Summer Faculty	5	18
Work Experience Trainee	35	13
Youth Opportunity Trainee	87	14
Science and Technology Student	6	8
<b>Total</b>	<b>181</b>	<b>111</b>

Typically, about 300 students and faculty members are temporarily employed each year at a cost of about \$2 million. For fiscal year 89, the cost was \$1.8 million. The projected cost for fiscal year 90 is \$2 million. Often, more than half of these employees come from New Mexico high schools, colleges, and universities—and, in several instances, the temporary programs are limited to New Mexico residents. The Work Experience Trainee and Youth Opportunity Trainee programs are almost entirely for New Mexico high-school students, and serve as effective community outreach tools. They provide economically disadvantaged high-school and post high-school students an opportunity to practice vocational skills and to earn money for further schooling. The Secretarial Skills Building Program targets minority candidates who receive an intensive 6-month in-house course designed to develop or polish secretarial skills. Applicants for the program, most from the state, are usually offered jobs at Sandia after successful completion of the course. This program is not currently populated because of recent hiring limitations at Sandia.

In fiscal year 89 Sandia employed 292 students and faculty members, including 181 from New Mexico. The program cost \$1,798,600. Students received \$1,308,600 of this amount. Faculty members received \$490,000. At \$488,000, the Outstanding Student Summer Program was the most expensive, while the University Summer Faculty Program cost \$333,500 and the Youth Opportunity Trainee Program cost \$313,100.

Here are brief descriptions of these temporary programs:

**Career Exploration Program**-Gifted high-school seniors gain engineering experience at Sandia. Candidates are selected by Albuquerque Public School employees and work about 20 hours a week at Sandia.

**Faculty Sabbatical Program**-Selected professors are brought on-roll as temporary employees, usually for one year, to work on research and development projects specified by Sandia organizations.

**Graduate Business Intern Program**-Outstanding graduate business students from UNM gain relevant work experience. Candidates are recommended by their faculty and placement office.

**Graduate Engineering Intern Program**-This program enables highly qualified graduate engineering students to integrate their academic programs with related work experiences. It is an effective means of attracting outstanding students to UNM's graduate program. UNM screens the candidates and refers them to Sandia's Staff Recruiting office. The Sandia organization that can provide appropriate training and professional experience makes the selection.

**Student Internship Program**- Highly qualified graduate students are provided the opportunity to integrate their academic program with related work experience. The program has a secondary purpose of attracting outstanding students to the graduate program at UNM.

**NMSU Summer Drafting Program**-This program provides first-year NMSU students work experience; Sandia drafting organizations recruit for the program.

**Outstanding Student Summer Program**-Outstanding students in engineering and science programs at the junior level or above are exposed to Sandia's environment.

**Secretarial Skills Building Program**-This program develops secretarial skills, targeting minority candidates for future employment at Sandia. Applicants are pretested and interviewed, then enrolled in a 6-month intensive skills-building program.

**Summer Teacher Enrichment Program**-New Mexico high-school and middle-school science and mathematics teachers upgrade their knowledge of science and technology through summer employment at Sandia. The program is coordinated by NMIMT.

**Undergraduate Engineering Co-Op Program**-Sophomore-, junior-, and senior- level students gain work experience in engineering and computer science. Work periods alternate with academic study periods. The program is coordinated with specified universities with high minority enrollments.

**University Summer Faculty Program**-This program is designed to attract outstanding professors from universities throughout the country who will make meaningful contributions to Sandia's technical work. At the same time, the professors have interesting and meaningful work to perform here. Two types of professors are sought: authorities in a technical field who can perform important technical functions and can provide consultative and guidance services and professors with outstanding qualifications for more specific, project-oriented assignments.

**Work Experience Trainees Program**-This program provides part-time employment and job experience to economically disadvantaged high-school and post high-school students enrolled in a cooperative education training program. Preference is given to applicants with economic need, high scholastic performance, and favorable recommendations from teachers.

**Youth Opportunity Trainee Program**-YOT offers summer employment to economically disadvantaged high-school and post high-school students, thereby providing valuable job experience and a source of income for further education. Preference is given to applicants with economic need, high scholastic performance, and favorable recommendations from teachers.

**Science and Technology Alliance Student Summer Program**-This program consists of three minority universities - New Mexico Highlands, North Carolina A&T, and Ana G. Mendez Education Foundation (Puerto Rico). DOE funds this program. Participants are students and faculty in science and math disciplines, at the college sophomore through graduate levels.

**Summer Employment for Minority Youth-** SEMY is proposed to employ pre-college (grades 11 and 12) and early college freshman and sophomores who are minority students with high achievement in math, science, and (at college level) engineering disciplines.

## **Summary of Sandia Partnership With Education in New Mexico**

Sandia continues to expand its interactions with higher education in New Mexico. As Tables 7 points out, activity has steadily increased since fiscal year 87 from just under \$7 million in resources allocated to nearly \$9 million in fiscal year 89.

Long-established relationships (namely, SURP, Educational Assistance, other research contracts, etc.) remain important elements in Sandia's partnership with education in New Mexico. However, a number of new initiatives have added to Sandia's commitment during the past two years. The Science and Technology Alliance is one that stands out. Under the general umbrella of "Educational Outreach," the Alliance includes New Mexico Highlands University as one of its targeted institutions to receive assistance. Sandia has already committed over \$500,000 in resources to New Mexico Highlands University.

An area of special interest and significant growth is "Research with Product Potential." Several breakthroughs occurred that can lead to valuable economic impact on the state. The examples outlined earlier in this report are but a few of the cooperative efforts underway between Sandians and faculty from New Mexico's research universities. Involvement like this is resulting in products being manufactured or research being conducted by industry in New Mexico.

**Table 7. Sandia Partnership With Education in New Mexico  
FY87 Through FY89**

	<b>FY87</b>	<b>FY88</b>	<b>FY89</b>
Contracts	\$4,028,000	\$4,771,000	\$5,496,000
Educational Outreach	25,000	25,000	290,000
Equipment	1,736,000	2,407,000	2,015,000
Temporary Employment	1,167,000	1,140,000	1,021,000
Total	\$6,956,000	\$8,343,000	\$8,822,000



## Appendix A. Impact of New Mexico Higher Education on Sandia

The following tables give details of the impact higher education in New Mexico has on Sandia.

**Table A-1. Number of Degrees at Sandia by State**

Rank	State	PhD	Mas	Bch	Sub Total	% of Sub Total	AAS	Total	% of Total
1	New Mexico	110	828	1090	2028	22.3%	618	2646	22.9%
2	California	238	452	367	1057	11.6%	274	1331	11.5%
3	Texas	111	244	363	718	7.9%	135	853	7.4%
4	Illinois	138	188	168	494	5.4%	251	745	6.4%
5	New York	85	109	169	363	4.0%	104	467	4.0%
6	Oklahoma	24	96	158	278	3.1%	74	352	3.0%
7	Michigan	43	92	132	267	2.9%	13	280	2.4%
8	Indiana	55	92	115	262	2.9%	79	341	2.9%
9	Arizona	35	110	104	249	2.7%	105	354	3.1%
10	Colorado	23	74	148	245	2.7%	57	302	2.6%
	Other	491	919	1708	3118	34.3%	783	3901	33.7%
	Total	1353	3204	4522	9079	100.0%	2493	11572	100.0%

Note: Other includes all other states and countries  
AAS is a two-year Associate degree

**Table A-2. High-Degree Counts by State for Regular On-Roll Employees**

Rank	State	PhD	Mas	Bch	Sub Total	% of Sub Total	AAS	Non Degree	Total	% of Total
1	New Mexico	106	708	432	1246	29.1%	489	1515	3250	32.8%
2	California	237	279	82	598	14.0%	172	246	1016	10.3%
3	Texas	109	133	56	298	7.0%	89	56	443	4.5%
4	Illinois	134	64	17	215	5.0%	190	46	451	4.6%
5	New York	82	35	21	138	3.2%	76	41	255	2.6%
6	Arizona	34	80	19	133	3.1%	61	13	207	2.1%
7	Oklahoma	24	71	30	125	2.9%	51	17	193	2.0%
8	Colorado	23	55	45	123	2.9%	37	30	190	1.9%
9	Indiana	55	51	13	119	2.8%	62	17	198	2.0%
10	Missouri	13	66	23	102	2.4%	78	18	198	2.0%
	Other	498	444	239	1181	27.6%	444	386	2011	20.3%
	Total	1315	1986	977	4278	100.0%	1749	2385	8412	85%

Note: Other includes all other states and countries  
AAS is a two-year Associate degree  
Non-Degree includes high-school diploma and college attendance without degree

**Table A-3. High Degrees for Sandia Albuquerque Management and Staff**

<b>Classification:</b>	<b>MTS</b>		<b>MLS</b>		<b>DIV</b>		<b>DEPT</b>		<b>DIR</b>	
<b>Total Population:</b>	<b>2495</b>		<b>497</b>		<b>481</b>		<b>128</b>		<b>31</b>	
<b>School</b>	<b>% by</b>		<b>% by</b>		<b>% by</b>		<b>% by</b>		<b>% by</b>	
	<b>Number</b>	<b>School</b>	<b>Number</b>	<b>School</b>	<b>Number</b>	<b>School</b>	<b>Number</b>	<b>School</b>	<b>Number</b>	<b>School</b>
University of New Mexico	436	17.5%	158	31.8%	120	24.9%	39	30.5%	4	12.9%
Stanford University	105	4.2%	0	0.0%	20	4.2%	4	3.1%	1	3.2%
University of Illinois	101	4.0%	3	0.6%	20	4.2%	4	3.1%	3	9.7%
New Mexico State University	75	3.0%	21	4.2%	9	1.9%	0	0.0%	0	0.0%
University of Texas	68	2.7%	11	2.2%	13	2.7%	1	0.8%	0	0.0%
Purdue University	65	2.6%	1	0.2%	17	3.5%	4	3.1%	0	0.0%
Oklahoma State University	65	2.6%	2	0.4%	12	2.5%	4	3.1%	2	6.5%
University of Arizona	52	2.1%	6	1.2%	14	2.9%	1	0.8%	0	0.0%
Texas A&M University	51	2.0%	1	0.2%	7	1.5%	2	1.6%	2	6.5%
University of California	42	1.7%	2	0.4%	5	1.0%	4	3.1%	1	3.2%
NM Inst of Mining & Tech	13	0.5%	0	0.0%	2	0.4%	0	0.0%	0	0.0%
NM Highlands University	7	0.3%	38	7.6%	6	1.2%	0	0.0%	0	0.0%
College of Sante Fe	0	0.0%	5	1.0%	0	0.0%	0	0.0%	0	0.0%
Eastern NM University	0	0.0%	11	2.2%	2	0.4%	1	0.8%	0	0.0%
University of Phoenix	0	0.0%	0	0.0%	1	0.2%	0	0.0%	0	0.0%

Note: Schools selected are top 10 universities for MTS population, plus five other New Mexican universities.

**Table A-4. Degrees from New Mexico Colleges and Universities**

<b>Degree Field</b>	<b>PhD</b>				<b>Master's</b>				<b>Bachelor's</b>			
	<b>UNM</b>	<b>NMSU</b>	<b>NMIMT</b>	<b>Other</b>	<b>UNM</b>	<b>NMSU</b>	<b>NMIMT</b>	<b>Other</b>	<b>UNM</b>	<b>NMSU</b>	<b>NMIMT</b>	<b>Other</b>
Engineering	41	6	0	0	345	43	1	0	217	107	0	1
Physics	5	5	0	0	14	7	2	0	11	9	10	4
Math	9	1	0	0	12	1	1	0	31	5	4	20
Chemistry	11	2	0	0	8	1	0	0	39	11	4	16
Other Science	6	1	3	0	9	1	7	0	57	10	2	34
Business	0	0	0	0	112	15	0	73	94	27	0	121
Computing	8	3	0	0	119	15	2	1	47	12	5	23
Other	9	0	0	0	36	0	0	2	120	10	0	33
<b>Total</b>	<b>89</b>	<b>18</b>	<b>3</b>	<b>0</b>	<b>655</b>	<b>83</b>	<b>13</b>	<b>76</b>	<b>616</b>	<b>191</b>	<b>25</b>	<b>252</b>

DISTRIBUTION:

1	A. Narath	1
20	O. E. Jones	1
30	L. E. Bray	1
400	G. Yonas	100
1000	V. Narayanamurti	1
1800	R. J. Eagan	5
2000	G. T. Cheney	1
3100	L. H. Pitts	1
3161	N. S. Hey	5
3500	R. C. Bonner	1
3520	D. K. Brown	1
3530	A. M. Torneby	1
3700	R. R. Russell	5
4000	M.R. Kestenbaum	1
5000	E.H. Beckner	1
7000	R. L. Peurifoy	1
8000	J.C. Crawford	1
8524	J. A. Wackerly	1
9000	R.L. Hagengruber	1
9001	M. A. Wartell	1
3141	S. A. Landenberger	5
3141-1	C. L. Ward (OSTI)	8
3151	W. I. Klein	3

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