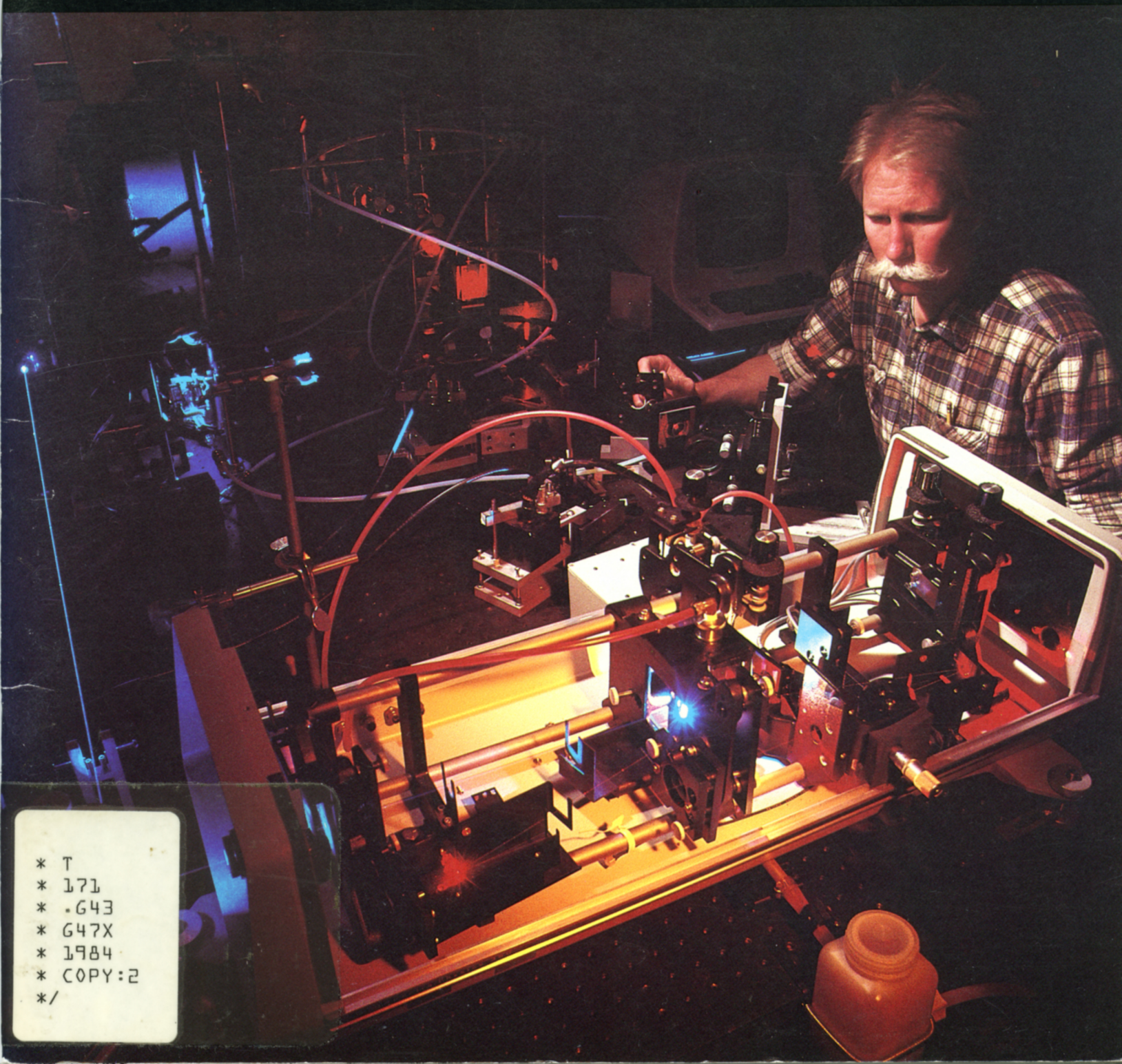
Engineering Experiment Station
Georgia Institute of Technology

1984 Annual Report

A Unit of the University System of Georgia



A New Era

For some years, EES' name has not adequately described the scope of its activities.

The Engineering Experiment Station not only serves the development needs of the state of Georgia; it now also conducts large research programs for both national and international governments and for industrial organizations. The Station's work has also grown beyond engineering to include research in many scientific disciplines and the broad application of science and technology in economic development programs. In rec[illegible] of this breadth of activity, EES will become the Georg[illegible] Research Institute — or GTRI — on October 1, 1984.

The Station's missions will not change, but its ide[illegible] better reflect the depth and diversity of its work.

Those who are familiar with Georgia Tech may be aware that GTRI has been the name of a nonprofit contracting corporation for Georgia Tech research contracts. This office has now become the Georgia Tech Research Corporation. Its mission likewise will remain unchanged.

cover

EES researchers use this laser to study complex chemical reactions which influence the behavior of the atmosphere.

Mission

In years past, one of America's chief sources of strength and prosperity has been its advanced technology. Today, competition at home and abroad has only increased the pressure for technological innovation. For this reason, the work of engineers and scientists has taken on a greater importance, whether it calls for process modifications in a small industrial plant or advanced designs for a space station to orbit the earth. This report focuses on one year at the Georgia Tech Engineering Experiment Station (EES), a fulltime, nonprofit engineering and scientific research organization whose scope of activity stretches from one end of this spectrum to the other.

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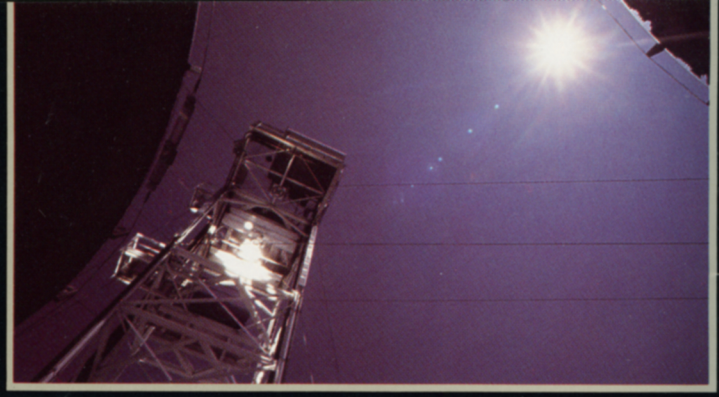


The Station operates one of the largest experimental solar thermal receivers in the country, the Advanced Components Test Facility.

Dr. Donald J. Grace

Letter from the Director

Technology is expanding at an unprecedented rate today in virtually every facet of our lives. To mention just a few examples:

- The revolution in microelectronics is bringing powerful tools for information processing into our homes.
- American companies are seeking a better blending of computer control and human intelligence to help improve productivity in the industrial economy.
- Military systems are evolving so rapidly that the armed services are constantly updating technology for national defense.

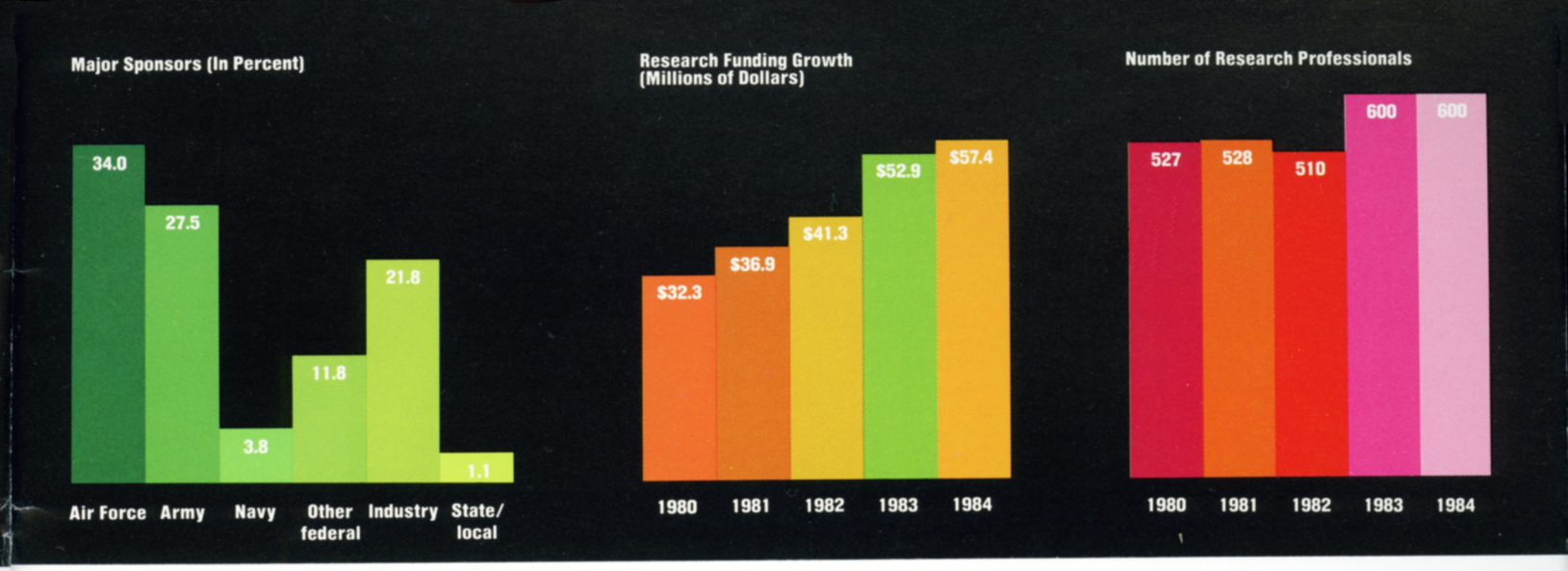
If these challenges are to be met effectively, engineering research will continue to be a necessity. One of the nation's emerging leaders in this field is Georgia Tech's Engineering Experiment Station (EES).

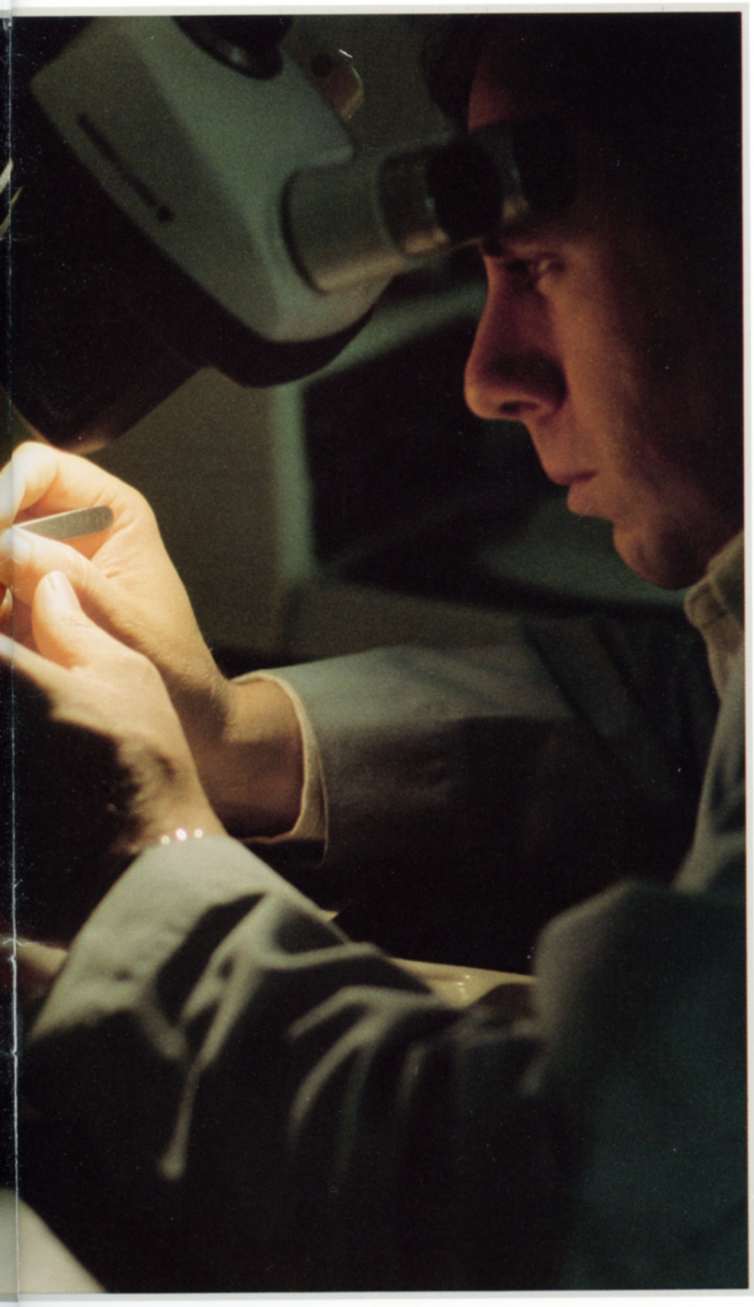
The Station (as EES is called) is recognized internationally for the diversity of its engineering capabilities. It is best known for the depth of its experience in electronics research, particularly for national defense needs, but programs are growing steadily in areas such as industrial productivity, computer technology, environmental control, materials development, international development and renewable energy.

The Station's growth rate was modest in FY 1984, but significant actions were taken during the year which pave the way for future expansion. Most notably, a newly organized nonprofit organization set up to assist public education in Georgia took two initiatives to ease pressing laboratory and office space problems at EES. This group, the Georgia Scientific and Technical Research Foundation (GSTRF), began construction of a $12.5-million research building on the Georgia Tech campus with the intention of leasing the 400-employee facility to EES and other Georgia Tech research activities when it opens in 1985. GSTRF also concluded contract negotiations for the purchase of a six-building complex owned by Lockheed-Georgia and previously leased to EES for several of its research laboratories.

Besides enhancing established bases of research, the Station made a number of technical initiatives which are noted on the next page of this publication. One reason that activity in new R&D areas was strong in FY 1984 was an innovative program

EES makes wire bonds which electrically connect integrated circuits to package leads.





for recruiting outstanding senior researchers to Georgia Tech. The Office of the Vice President for Research provided funds to hire these research professionals and support them for several years in building R&D programs on campus in targeted research fields. These senior researchers will help EES and academic units to grow in new technical areas.

Facilities to support EES' research program continued to expand during the year. Most notably, construction began on a $1-million state-of-the-art antenna measurement range.

Interaction with the industrial community during the year was extensive. Roughly 20 percent of EES' contracts were industrially sponsored, a proportion which is five times the national average for universities. The Station enhanced its ability to assist industry in the state of Georgia when the State General Assembly approved funding to establish four new field offices.

1984 was a year of substantial program activity for the Station in foreign countries. One of the most significant developments was Georgia Tech's agreement to market its research capabilities, inventions, patents and licensable technology in Japan through Nissho Iwai, a major Japanese trading company. In addition, the Station established a headquarters in Cairo, Egypt to administer a major project of industrial assistance for that country. EES also initiated resident engineering assistance programs in Khartoum, Sudan, and in Guatemala City, Guatemala.

Unfortunately, the European Research Institute of Ireland (ERII), a contract R&D center managed by EES, closed after two years of operation. The original plan called for a five-year program to create and establish ERII as a self-sufficient R&D organization. However, additional capital required to continue the project was not made available.

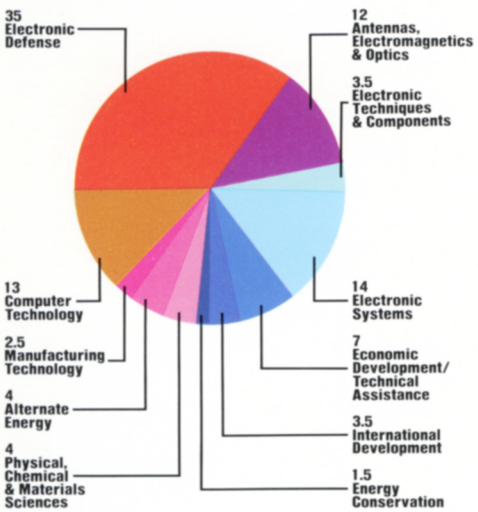
Overall, FY 1984 was a good year for EES and one in which we were able to strengthen the foundation necessary for future organizational growth. We thank you for your support in these endeavors and hope to continue this relationship in the future.

Donald J. Grace

Donald J. Grace
Director, Engineering Experiment Station

This drawing shows an architect's rendering of a new research building under construction at Georgia Tech.

Distribution of Sponsored Research Areas — FY 1984 (In Percent)



New Technology Initiatives

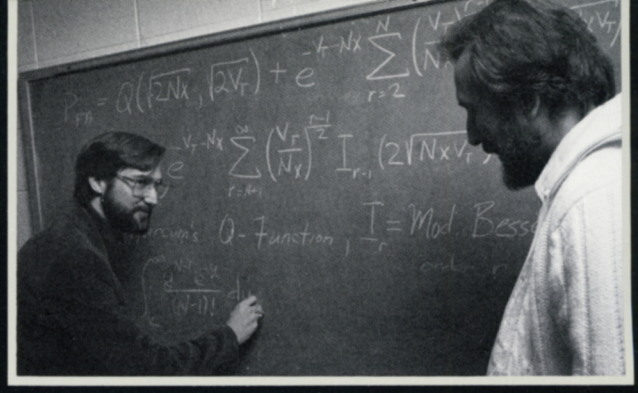
In 1984, EES made a number of new technical initiatives and strengthened R&D programs which have developed over the past several years. This research involved topics such as:

- Hazardous waste management
- Robotics
- Thermoelectric power generation
- Zeolites
- Membranes
- Integrated optics
- Networking and office automation
- Biomedical ultrasound
- Computer applications in medicine
- Millimeter wave integrated circuits
- Electronic durability
- Deceptive techniques for countermeasures
- Millimeter wave communications
- Radar tracking and weapon systems
- Laser radar
- Coherent pulsed Doppler radar
- Guidance and seeker technology
- Fiber optics
- Expert systems
- Directed energy weapons electromagnetic compatibility
- Data communications networks
- Spread spectrum electromagnetic compatibility
- Inverse scattering
- Microwave imaging
- Array antennas

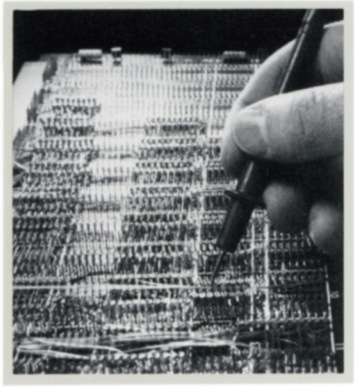
This EES materials degradation experiment is flying on a NASA satellite.

The Station is nationally known for its work in microelectronics durability studies.

Research Highlights



Analytical studies are the backbone of EES' reputation in the electronic defense field.



EES engineers are experienced fabricators of prototype hardware for military test and measurement systems.

Electronic Defense

In 1984, EES sharpened its R&D focus in receiver/processors. These systems detect and analyze radar threats to military aircraft, warning pilots of their presence or allowing an automatic response with the appropriate jamming techniques. Sponsored R&D in this field has increased to the point that the Station fully integrated its project work in analysis and in technology insertion. EES electronic defense specialists now are better positioned to formulate plans which assist the Department of Defense in designing its next generation of receiver/processors.

For the past three years, EES has maintained a field office at Eglin AFB, Florida, to assist the Air Force with a variety of electronic defense research needs. Notable R&D efforts included a testing program for an advanced radar warning receiver, the ALR-74, and support for the Air Force's Green Flag Office, which is undertaking a tactical modeling program. In addition to the Eglin Field Office, the Station established an office in FY 1984 at Warner Robins, Georgia, to act as liaison between EES and the Warner Robins Air Logistics Center.

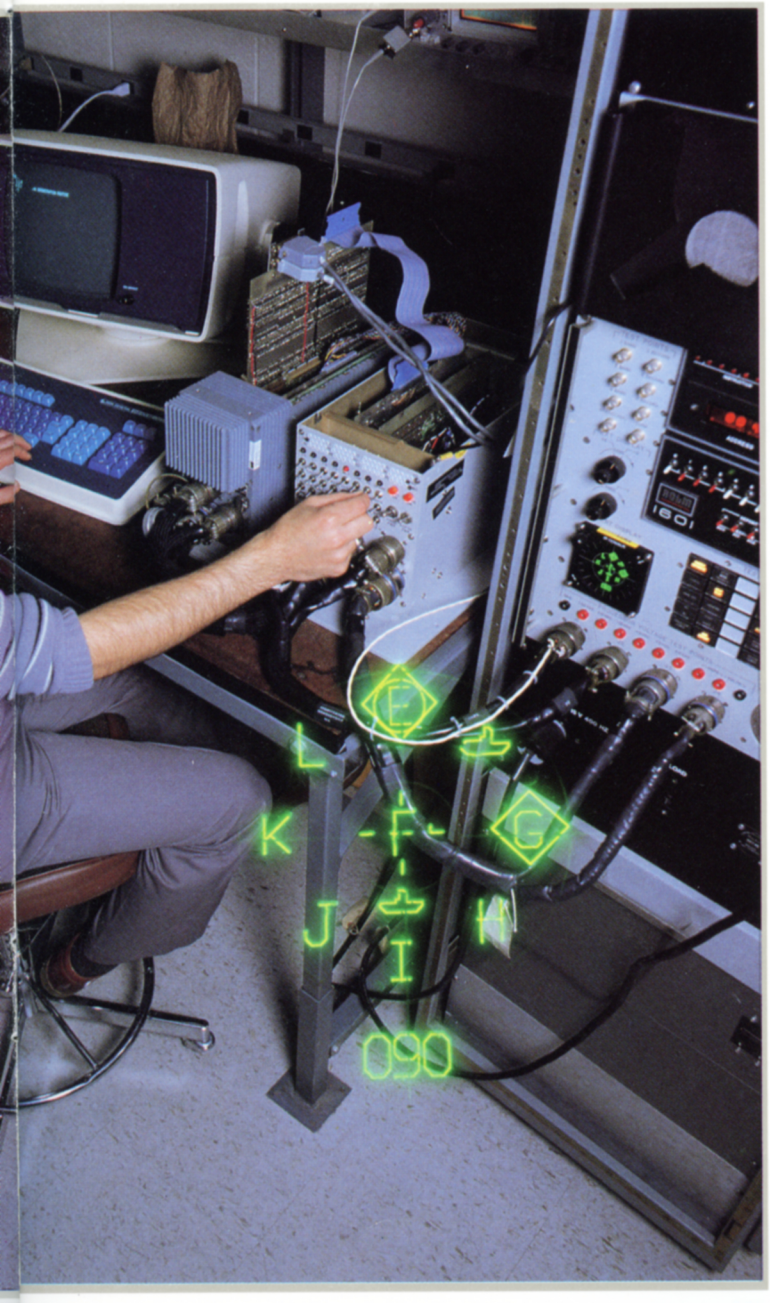
In the area of software engineering, an EES representative was a member of a technical committee which is defining the ancillary software necessary to support Ada, the Department of Defense programming language. Station engineers also conducted a $1 million effort to develop automated tools for evaluating electronic defense software. This project has produced a uniquely capable analytical tool for evaluating any FORTRAN 77 software.

During 1984, EES completed and delivered an integrated support station which will provide a test bed for evaluations of the entire F-15 aircraft Tactical Electronic Warfare System. Through this $1.3-million program, engineers developed a powerful feature for support stations, the ability to collect performance data in real time.

Another important activity of the past fiscal year was the application of very high speed integrated circuits (VHSIC) to electronic defense systems. The threat environment facing aircraft in any future conventional military conflict promises to be sufficiently dense that pilots will need a variety of jamming tech-

In FY 1984, EES fully integrated its work in receiver/processors

The Station maintains two Convair aircraft for research programs requiring airborne data measurements.



niques to evade different enemy radars. VHSIC technology will allow more jamming equipment with greater capability and flexibility than current systems possess to be installed in a smaller space on an airplane. Warner Robins AFB has contracted with EES to evaluate the fabrication and installation of VHSIC chips by a commercial contractor into an ALQ-131 electronic countermeasures (ECM) system. Of greater potential significance to the Station is its proposal to incorporate VHSIC technology into a generic system it has designed for generating a wide variety of jamming signals from an aircraft. EES will receive funding from the Department of Defense to build a prototype with commercially available logic and hopes to get support at a later date to develop a VHSIC version of this generator.

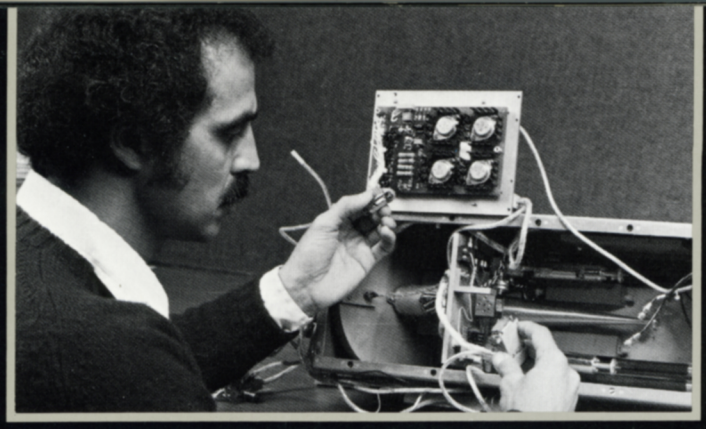
EES also was active in electronic countermeasures flight testing last year, concluding a 600 flight hour effort designed to assess the effectiveness of advanced ECM techniques against a variety of test radar systems. This effort was part of an Air Force Risk Reduction Program to determine advanced ECM hardware requirements.

The Station also continued to enhance its national reputation for excellence in the analysis of electronic defense concepts through modeling and simulation. The analyses performed have varied from detailed assessment of a single countermeasure technique against a specific weapon system function to the evaluation of the number of aircraft that would be lost while accomplishing a large-scale mission.

Electronic warfare techniques analysis, consisting of 42 different tasks with funding from all three military services, continues to be the largest program within the Station.

Other significant research in FY 1984 involved:

- Support in improvements to the ALQ-131 ECM pod.
- Extensive analysis of monopulse radar/ECM interactions
- F-16 electronic combat suite definition
- Field testing support of an advanced development version of an Air Force ECM pod.
- Field testing of an advanced development millimeter wave ECM system for the Army.
- Assessment of the susceptibility of remotely piloted vehicles to enemy missile systems.
- Development of a prototype which provides an interface between an ECM pod and a radar warning receiver.



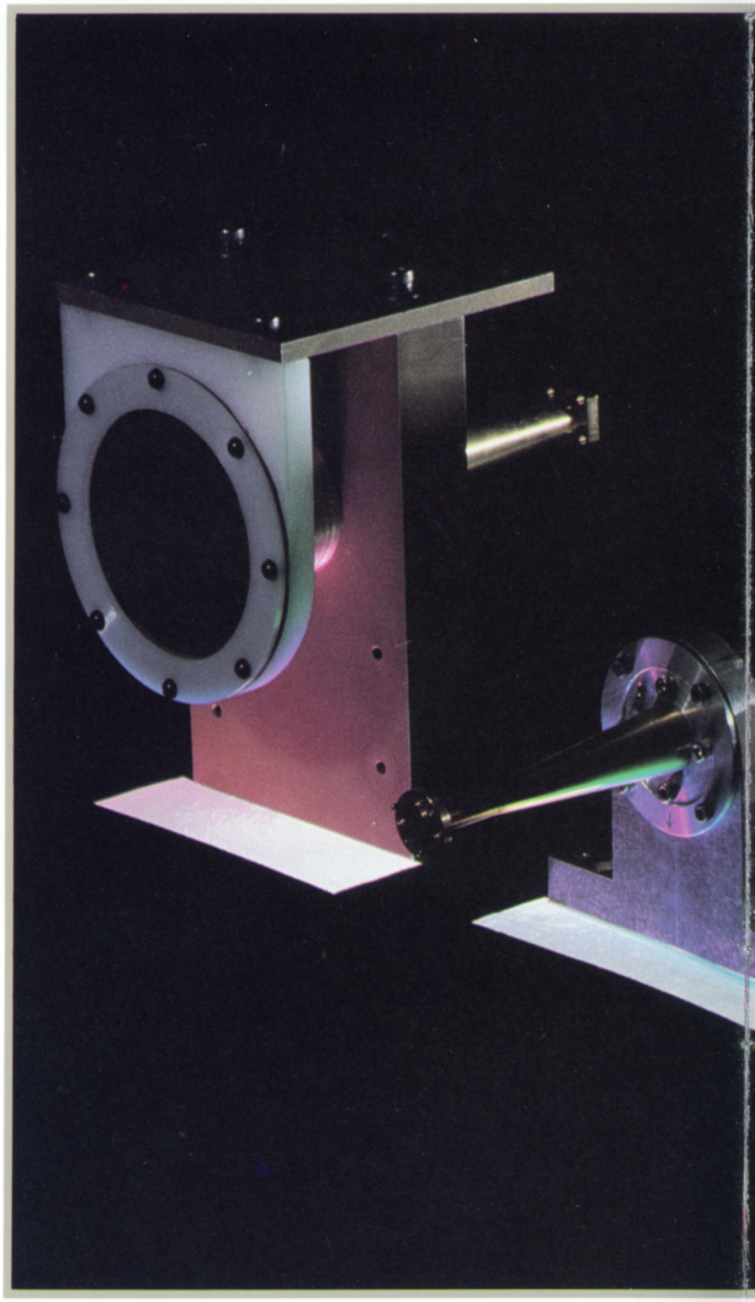
This 85.5 GHz radiometer has been used for airborne simulation in the Defense Meteorological Satellite Program.

Radiometry

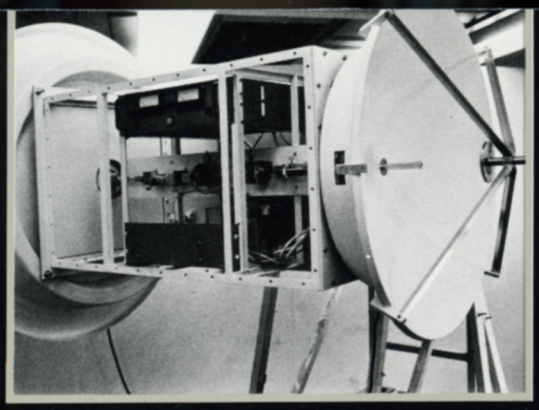
EES is extending the frontier of passive sensing with radiometric development programs in the millimeter wave band of the spectrum. In early FY 1984, the Station developed an airborne 85.5 GHz radiometer which the Navy plans to use to determine how atmospheric losses could affect the satellite detection of ground targets. The radiometer flew on board the Navy's low-altitude P-3 research aircraft in 1984, recording images which researchers will use to support the calibration of future satellite-generated data gathered on the same targets.

Work continued last year on EES' 94/183 GHz Advanced Microwave Moisture Sounder (AMMS), as the Station developed operating system software which enabled researchers to study images recorded in real time by the radiometer. The AMMS flew on Lockheed Research Lab's ER-2 high altitude research airplane, performing ground target detection measurements at 94 GHz and determining the effects of upper atmospheric water vapor on target detection with the three 183 GHz data channels. NASA also flew the radiometer in 1984 on board the ER-2 to gather severe storm data in the Midwest. Later in the year, EES researchers participated in a follow-up ice measurement program on board NASA's CU-990 flying laboratory to gather data on ice floes in the Greenland Sea as part of NASA's Marginal Ice Zone Experiment.

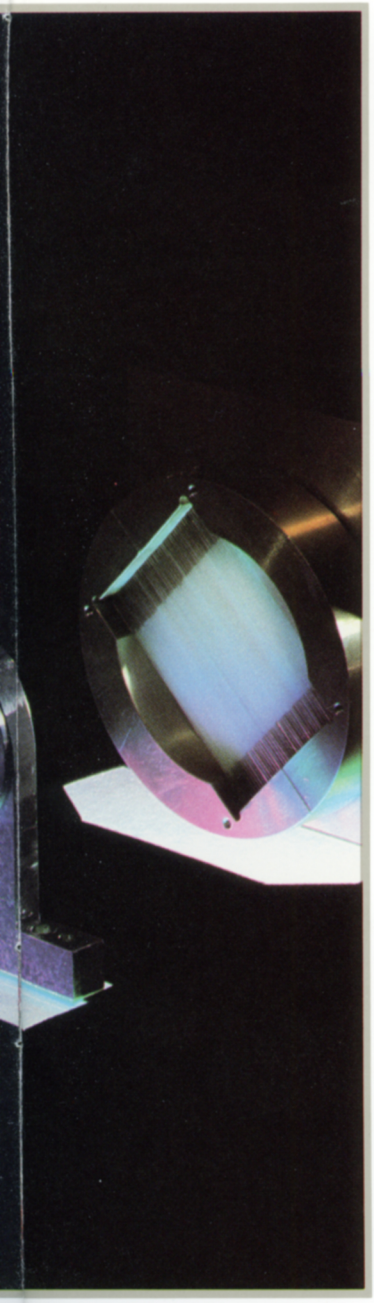
During the year, EES engaged in internally sponsored research directed toward a better understanding of the atmosphere and astronomical problems. Radiometers operating at 94/183 GHz determined the level of thermal fluctuations which can be seen by looking upward at the sky. This phenomenon is of interest to those attempting to establish millimeter wave tracking system performance limits. It is also important as an indicator of the atmosphere's dynamic structure. In connection with this area of research, Station engineers studied an annular solar eclipse near 95 GHz in May.



EES engineers are using meanderline and dielectric slab polarizers as parts of a state-of-the-art millimeter wave direction finding system being developed for the Army.



EES designed this dual-band millimeter wave illuminator.



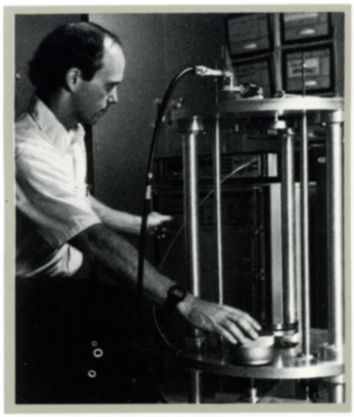
Millimeter Wave Technology

Thanks to the technology breakthroughs of research centers such as EES, the United States is now in a position to develop large millimeter wave systems for applications where the military must have secure communications, substantial information storage capacity in a single transmission, and effective imaging of battlefield scenes. In 1984, the Station increased its efforts to team up with private companies in proposals for large millimeter wave development contracts from the government. In the meantime, EES engineers continued to be active in important basic research and technology enhancement activities.

EES played a leading role in 1984 in a large and growing Army program to reduce the signatures of ground-based vehicles and other installations. This Multispectral Signature Suppression Program is a multi-laboratory effort organized to develop radically new camouflage and suppression techniques for the full spectrum of projected threat sensors. The program covers the microwave to infrared range, including millimeter wave sensors, a new threat of special concern.

During the year, EES researchers also performed extensive research for the Army on the radar backscatter properties of snow-covered terrain at millimeter wave frequencies. This environment is one of the most complex within which an autonomous millimeter wave target acquisition radar must operate. The Station's program was highly successful in obtaining the comprehensive data base necessary for the Army to quantify the nature of high backscatter snow. This knowledge will serve as a basis for predicting the effects of this environment on millimeter wave guided weapons proposed for future deployment.

In a basic research project, researchers from the Station conducted tests in a fully instrumented van to determine how turbulence in the atmosphere affects the angle of arrival of millimeter wave transmissions. Atmospheric conditions can have a pronounced effect on high-frequency signals, and the Army sponsors of this research hope to determine how turbulence in the air affects ground-to-ground millimeter wave links.



This five band Fabry-Perot interferometer is used for measurements of complex permittivity and permeability of materials.

The Station was a key member of the team which developed this Real Time Velocimeter System for the Army.

Radar

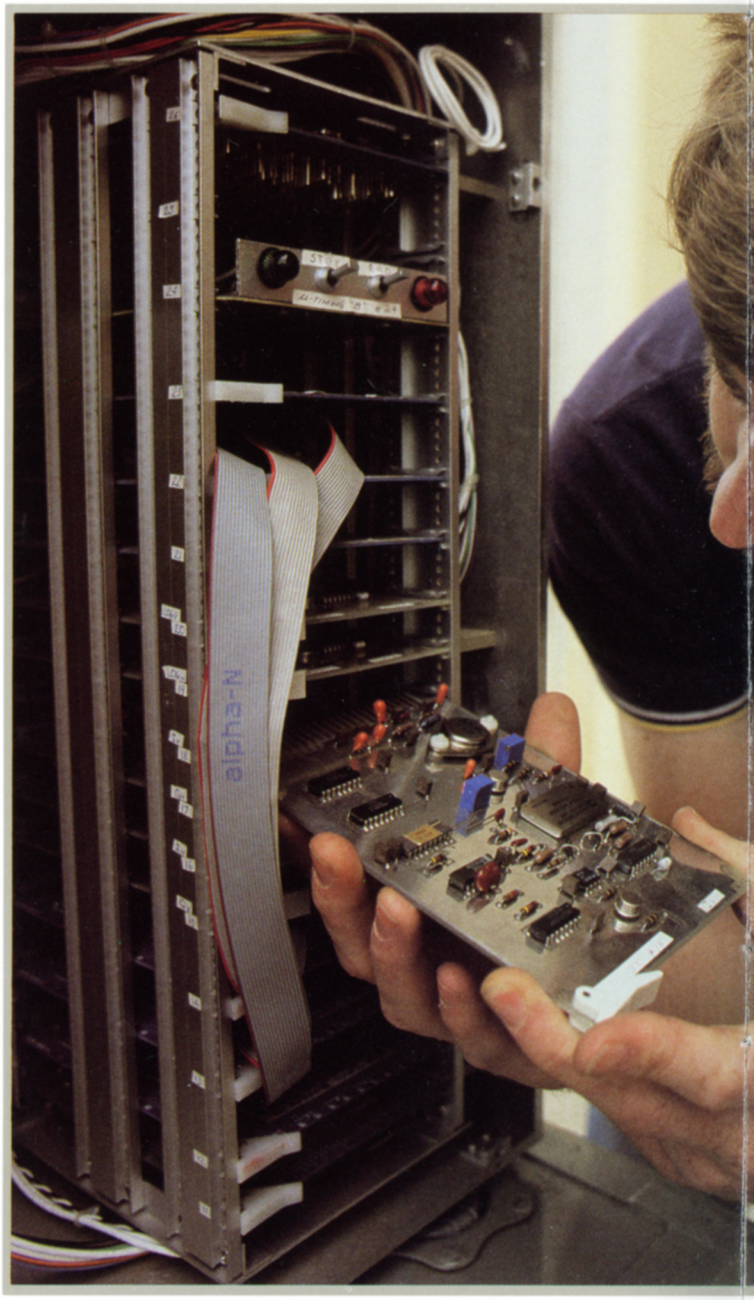
EES has worked actively in radar research since the end of World War Two, and a broad base of experience is in place at Georgia Tech for all types of R&D in this field, including large system development.

The Station has built many replicas of foreign threat radars and in 1984 completed two particularly ambitious projects. Early in the year, EES concluded a four year research program with the delivery to the U.S. Army of a massive radar installed in a modified tracked vehicle. The finished system weighs some 20 tons and cost approximately $8.7 million to build. It includes a tracking radar with an antenna nine feet in diameter as well as missile tracking and guidance equipment. This system replica permits American pilots to test tactics and equipment as if they were flying actual missions.

A multiple radar complex designed and built by EES under an $11-million research contract was installed recently at Eglin AFB, Florida. This radar, known as the Simulated Air Defense System (SADS) VIII, will be used by U.S. and NATO armed forces to study electronic countermeasures and defensive tactics. The SADS VIII system incorporates advanced antenna design and computer technology.

During the year, EES modified an Army instrumentation radar known as the AN/MPS-36 to improve its tracking performance and versatility. Station engineers converted the radar from a two to a three channel monopulse system, adding capabilities for target motion resolution and remote manual calibration. The Army uses this radar on its instrumentation ranges to track missile and aircraft targets, thereby providing a reference for evaluation of the performance of other radar systems and determination of target dynamics.

EES also provided on-site support to the USAERADCOM Combat Surveillance and Target Acquisition Laboratory in establishing a Non-Cooperative Target Recognition Center at Fort Monmouth, New Jersey. The mission of this center is to develop a technology base to enable airborne and Army ground radars to automatically detect and recognize moving and stationary targets. EES will formulate a detailed design for the center; install, operate and maintain the specialized electronic



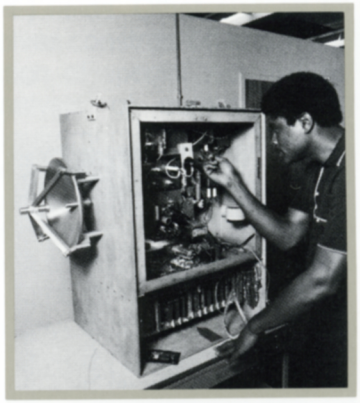
This 35 GHz, high resolution, full polarization matrix instrumentation radar collects reflectivity data on clutter and military targets.

equipment; and assist the Army in developing target recognition technology.

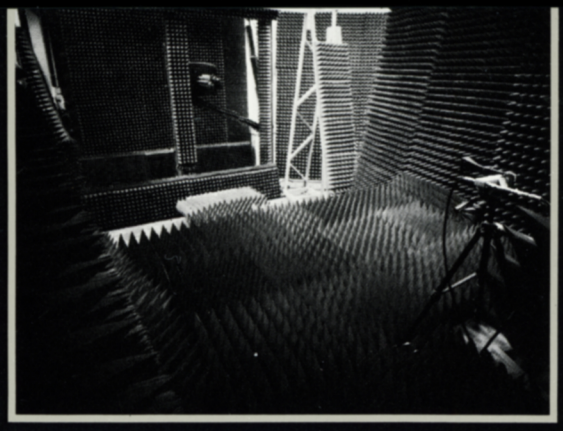
In the area of radar analysis, EES studied data concerning a foreign missile guidance radar and developed an understanding of its design and modes of operation. The system under investigation is a very complex radar of advanced design which has sophisticated signal processing and antenna design features. The Station's ultimate goal in this project was to develop concepts and techniques for countering this threat to U.S. forces. The work is continuing in a follow-up program involving another threat radar of advanced design.

In 1984, EES completed development of a dual-band (35 and 95 GHz) millimeter wave illuminator which was designed to transmit simulated radar signals for testing current and future airborne electronic warfare systems on ranges at Eglin AFB, Florida. A unique feature of this dual-band illuminator is its employment of a common high-voltage power supply and modulator to drive either the 35 or 95 GHz extended interaction oscillator transmitter tube on a selectable basis.

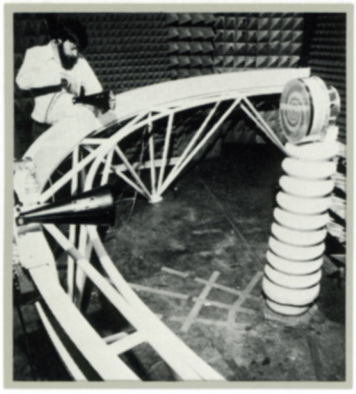
Another area of strong activity at EES last year was radar measurements. Engineers from the Station spent a month in the Canadian Arctic, measuring the backscatter properties of sea ice at 3, 10, 16 and 35 GHz. The primary purpose of this experiment was to determine unique radar signatures of multiyear ice and icebergs that will allow these ice types to be distinguished from first year ice at low depression angles from a shipboard platform. Preliminary results indicate that 10 and 16 GHz are the best frequencies for sensing these ice forms. An automatic discrimination technique may be developed by exploiting the difference in parallel-polarized and cross-polarized returns of first year and multiyear ice.



EES uses this 95 GHz instrumentation radar for collecting radar cross section data.



The Station uses one of the most precise near-field scanners available for electromagnetic aperture distribution measurements.



This reflectivity arch is used by the Station for broadband radar cross section measurements.

Antenna Development

EES continued last year to be active in antenna analysis, design and fabrication, a field in which it has maintained a national reputation for decades. The Station has built nearly all antenna types, from wire models to huge reflectors and phased arrays.

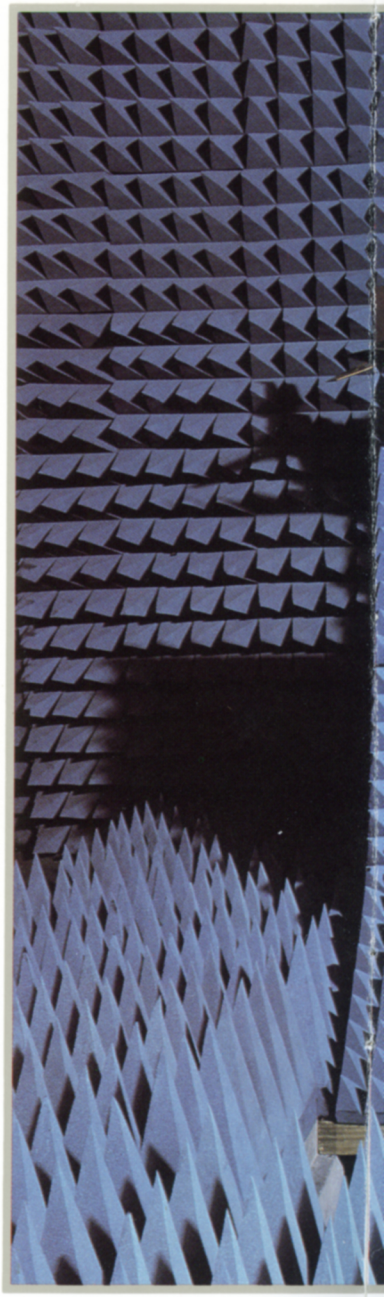
In one project, engineers designed and constructed two different types of multi-horn feeds for search radar applications. Another program called for the design of an eight-horn feed for an industrial sponsor. Both designs made extensive use of a Data General MV400 computer as well as EES' extensive library of antenna design programs.

Through an Air Force sponsored project, the Station developed mathematical models of the polarization properties of several types of reflector antennas and phased arrays. The models were verified by antenna pattern measurements.

Another significant program last year analyzed the effects of manufacturing errors on the performance of reflector antennas. The sponsor of this research, Scientific Atlanta, provided engineers with the required performance, and the Station calculated manufacturing die tolerances which were permissible given these requirements.

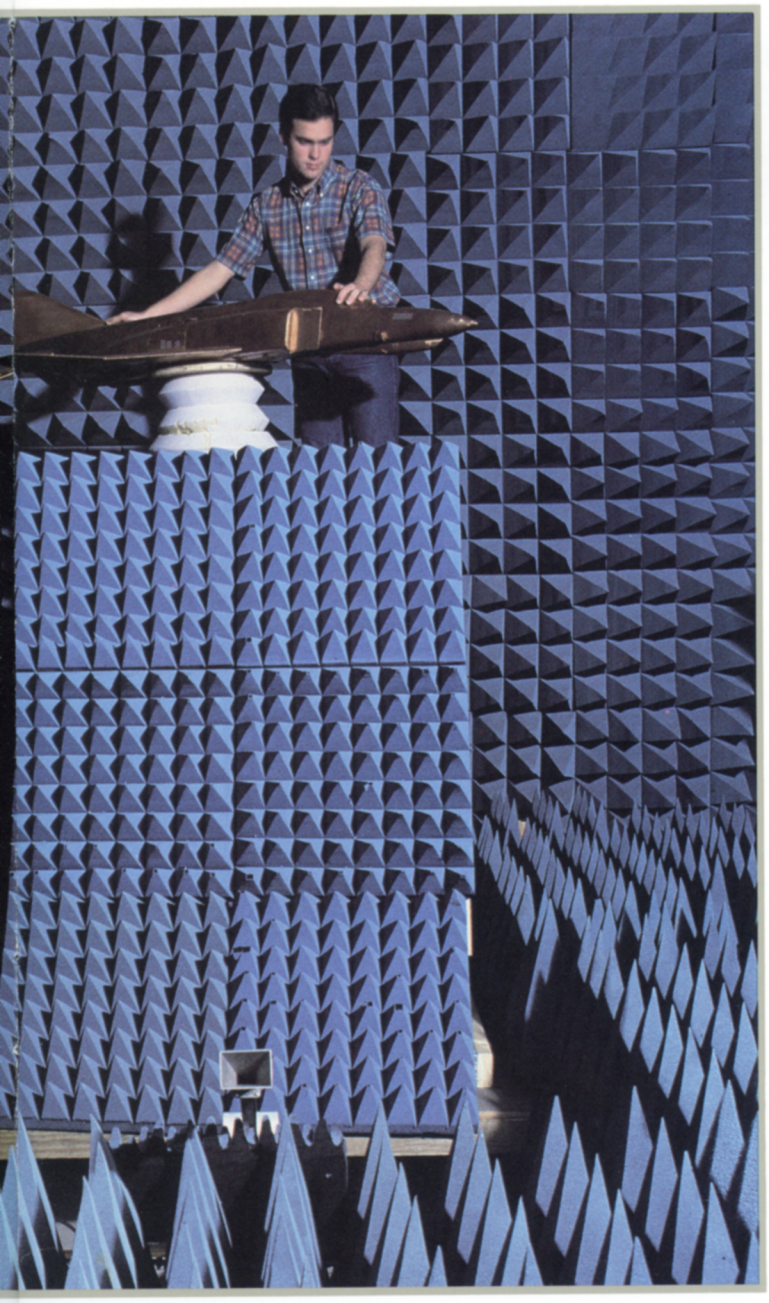
In addition, EES delivered the second S-band telemetry antenna for use in the MX missile program. The antennas fly aboard C-7 aircraft, collecting data on missiles descending at Kwajalein Missile Range several thousand miles southwest of Hawaii. The Station developed this prototype under subcontract to Kentron International, Inc.

Throughout the year, EES engineers exercised their considerable experience in antenna testing on Georgia Tech's outdoor and compact ranges and on several Tech instrumentation facilities. Of special significance was EES' ability to test antennas in the laboratory setting and project their performance in the real world. To further enhance this capability, EES began construction of a new antenna range at its Cobb County research complex in 1984. The new facility is designed for measurement of low-sidelobe antennas and will be fully automated through on-site and remote computers.



An engineer prepares for a simulated far field measurement in the EES compact range.

EES is studying millimeter wave-related electromagnetic compatibility problems.



Electromagnetic Compatibility

In 1984, Georgia Power Company learned that a high power phased array radar was to be built near one of its major communications relay stations. In response to the development, the utility company hired EES to assess potential interference problems, and engineers from the Station formulated a series of steps appropriate for combatting electromagnetic compatibility problems which may arise.

In another program, EES engineers began a study of how integrated circuits function in dense electromagnetic environments. This assessment will culminate in the formulation of measures to prevent these devices from being damaged or upset when used by the military in locations crowded with high frequency signals.

The Station also assisted the Navy in modernizing electromagnetic testing facilities for carrier-based aircraft. EES engineers are rewriting computer software to make tests easier to perform. They also are writing new software to allow additional types of testing of aircraft electronics in radio frequency (RF) fields. Other support involves construction and installation of special test fixtures, analysis of current testing requirements, identification of potential equipment shortfalls and assistance in procurement of equipment to meet the total testing requirements.

Other notable research during the year involved:

- Development and evaluation of specialized antennas
- Preparation of electromagnetic pulse protective design measures.
- Advice to the Air Force on the use and improvement of an anechoic RF test facility.
- Electromagnetic engineering design guidance to major utility systems.
- Evaluation of new product ideas for minority-owned businesses.

EES researchers characterize a wide range of materials, including microelectronics devices.

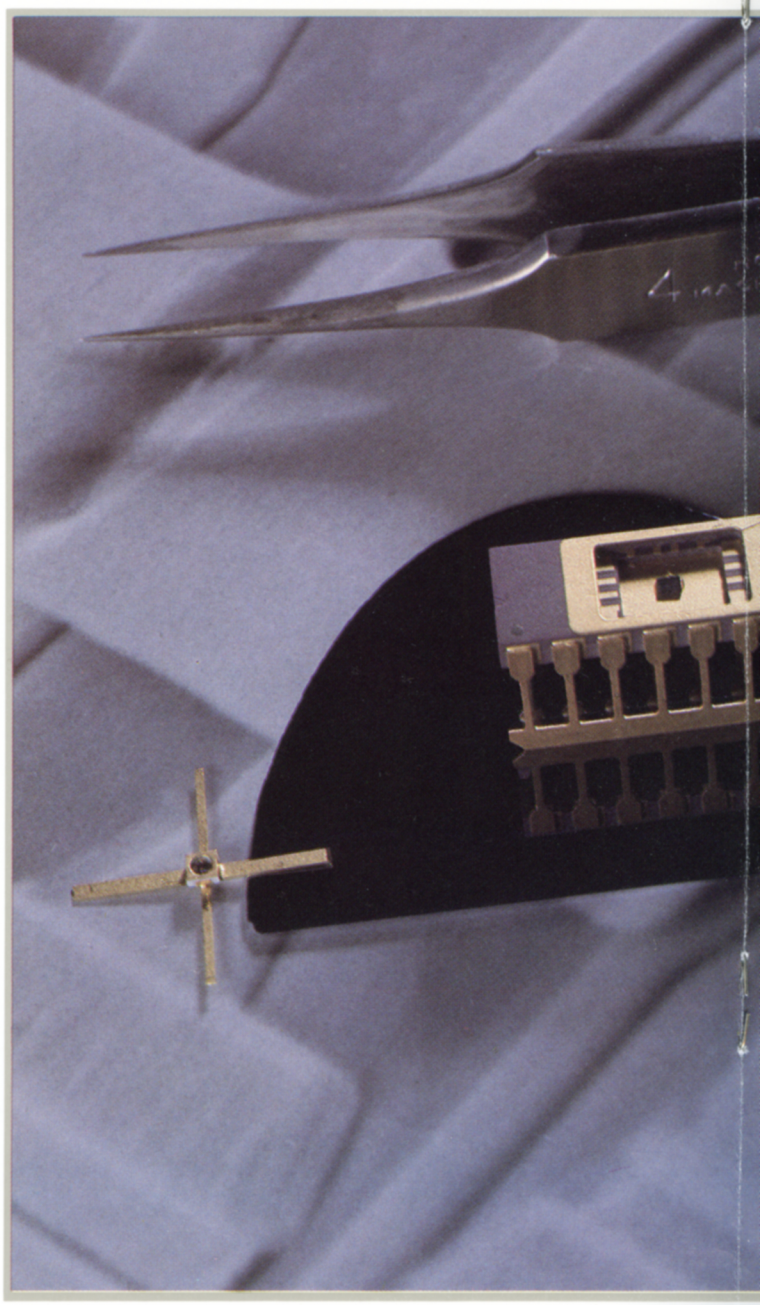
Microelectronics

During the past year, EES successfully demonstrated that molecular beam epitaxy is a viable technique for growing mercury cadmium telluride (HgCdTe) and cadmium telluride (CdTe). The Army currently is developing these materials as microelectronic chips for use in guided missile seekers and thermal imaging systems. In a related study, the Station investigated the potential of long-wavelength HgCdTe power cells for converting radiation emitted by the earth or powerful lasers directly into electrical power. This project demonstrated that high cell efficiencies could enable low-orbiting satellites to be remotely powered, and EES now is designing special device structures for this purpose.

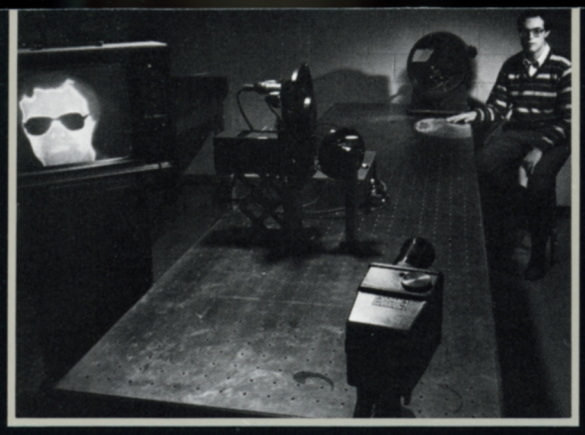
The Station's Micromechanics Laboratory continued to investigate the durability of microcircuit connections. Researchers attempted to correlate changes in the structural properties of bond wires with environmental stresses which lead to the breakdown of VLSI devices. They also used microtensile and microfatigue instrumentation to evaluate the physical properties of intraocular and contact lenses. These studies are measuring the performance of lenses under simulated use conditions which involve mechanical deformation.

Last year, EES researchers worked to develop a molecular beam epitaxy (MBE) technique for growing InGaAsP, a material to be used in integrated optoelectronic circuits. A successful outcome to this program will result in improved components and integrated laser/detector/modulator systems for optical fiber communication. Other microelectronics research activities in FY 1984 included:

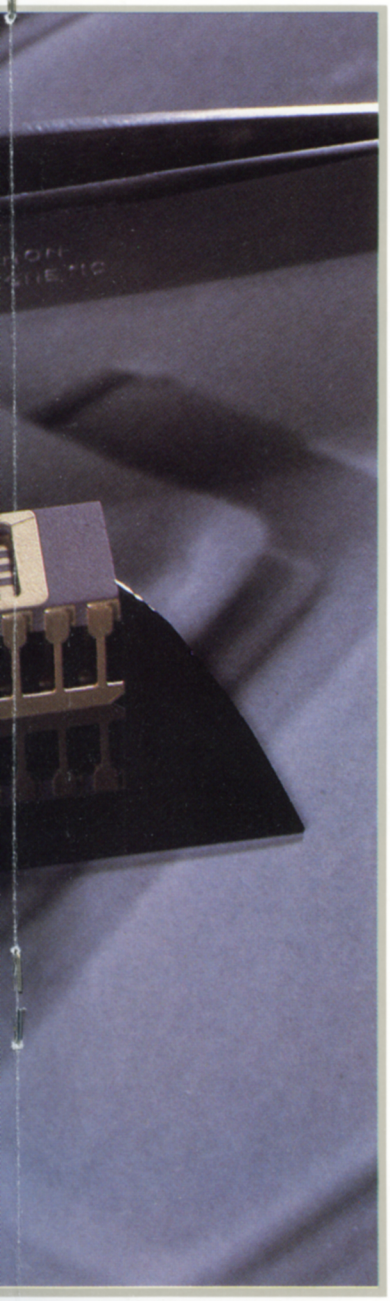
- An exhaustive study of the material properties of cadmium sulfide in relation to its use as an ultraviolet/visible Schottky barrier detector.
- Development of low noise gallium arsenide field effect transistors for X-band applications.
- Development of space-qualified millimeter wave mixer diodes.
- Studies of the physical properties of magnetic recording tape.
- Fundamental studies of electron attachment processes.



GaAs device fabrication, materials research and integrated circuit processes and packaging are areas of strong activity at EES.



This black body with masks measures the spatial and temperature resolution of infrared imaging cameras.



Infrared/Electro-Optics

EES is conducting long-term research to develop high order mathematical models of all the infrared missile seekers in the American defense inventory and many seekers in the arsenals of foreign countries. In 1984, engineers at the Station continued a program to develop digital models of infrared seekers. These models will provide simulated environments for testing and evaluation, and show military sponsors how to make American seekers more resistant to countermeasures.

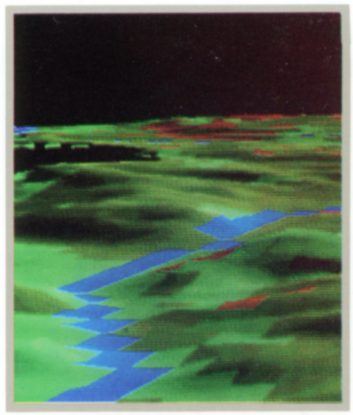
Researchers also continued studies to predict how guided missile sensors at infrared frequencies will perform in a variety of weather conditions and geographic terrains. Engineers working on this program concentrated on modeling a TV target acquisition system as well as TV and laser missile seekers. EES completed a theoretical model of the lock-on range for both laser-guided and TV-guided missiles.

EES began significant technical initiatives in the field of artificial intelligence. One program aims at improving target identification through development of a technique for automatically surveying the environmental context in which unclassifiable objects are detected. The Station also started work on an autonomous navigation system which would allow pilotless helicopters to generate mission plans for various environmental parameters.

Finally, geoprocessing specialists helped the Navy beef up security at a naval base where the president of the United States frequently lands. EES engineers examined data of the terrain surrounding the base and advised the Navy on the best sites for radar intrusion detection units.

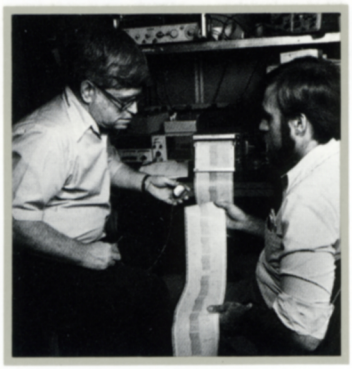
Other significant research dealt with:

- Integrated data analysis using LANDSAT and geographic data.
- Signature reduction for remotely piloted vehicles.
- Fabrication of an electro-optical tracker prototype.
- Development of terrain analysis features in microcomputers.
- Hardware development for a new infrared seeker facility.



EES researchers generated a three-dimensional perspective of a Georgia river basin with LANDSAT and elevation data.

EES is developing this monitor to allow remote sensing of the life status of battlefield casualties.



The Station is a well-known center for evaluations of industrial pacemakers.

Biomedical Electronics

It is known that bone has electrical properties, but the specific role that electricity plays in the healing of fractures is unknown. EES engineers began investigating this whole area in 1983-84. They are attempting to understand how an electric signal stimulates bone growth and healing, and how better to utilize a mechanism for promoting more rapid healing by means of magnetic coils. They also are investigating electrical stimulation of bone growth as a way to make hip replacement prosthetic devices more stable and more permanent. Another application would be to replace dentures with individual teeth, encouraging the jawbone to grow around them by means of electric stimulators in braces.

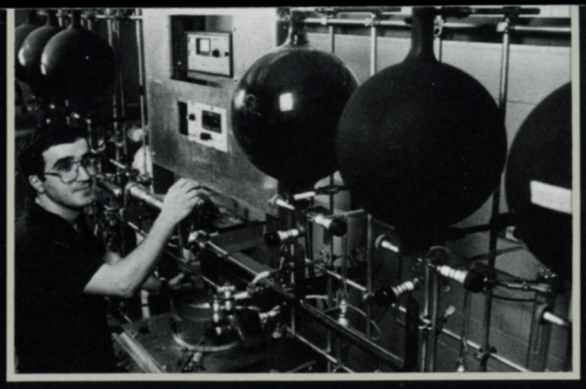
EES also assisted an orthopedist who has the world patent on a mechanical bone separator used in lengthening the legs of children who have one leg shorter than the other. The project involved incorporating an electric motor that could be externally activated by electromagnetic radiation. By this method, bone separation could be achieved without surgical intervention.

Modifications and refinements were completed on hyperthermic cancer treatment equipment designed and built by EES engineers, and it soon will be ready for tests on cancer patients. The equipment uses nonionizing electromagnetic radiation to selectively heat and kill malignant tissues, which absorb more radiant energy and thus get hotter than healthy tissue. Microwave energy is beamed to the cancer site by pairs of antennas attached to opposite sides of the body. EES also began working on designing antennas that will conform to the shape of the body in order to couple energy more efficiently to the patient.

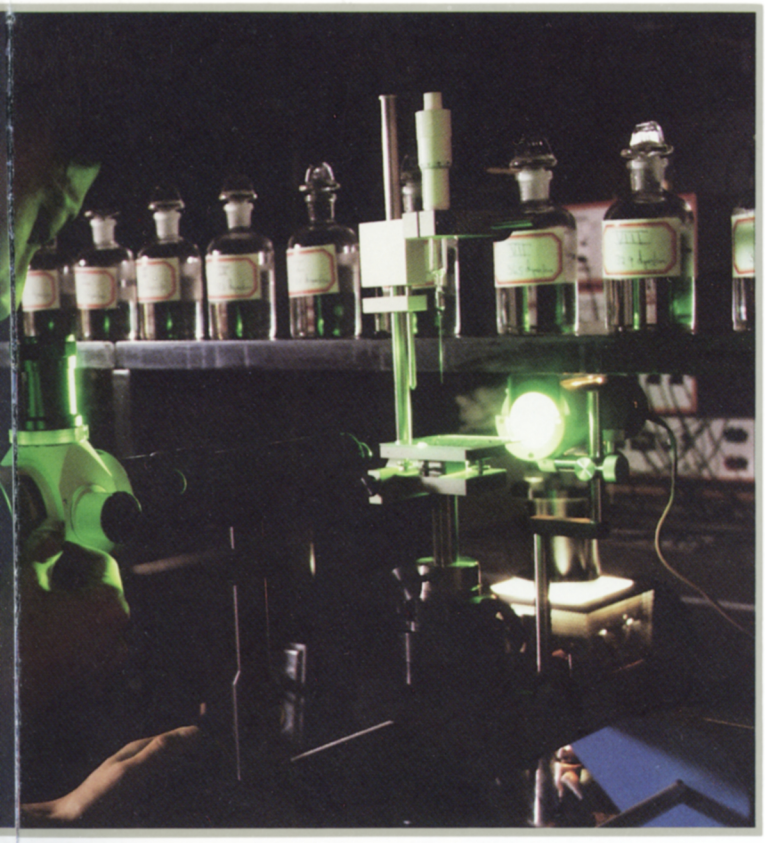
Other significant biomedical research during the year involved:

- Studies to create instruments for non-invasive monitoring of human vital signs from long distances.
- A multi-year study of the effects of microwave radiation on biological systems.
- Evaluation of the electromagnetic performance of cardiac pacemakers.
- Design evaluations for an implantable defibrillator.

This precision goniometer measures contact angles.



This apparatus gives EES the capability to create gas phase reactions important in combustion and atmospheric systems.



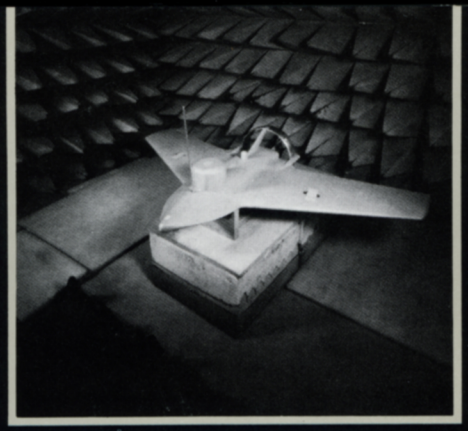
Chemical Sciences

EES' outstanding basic research in atmospheric chemistry has made it a world leader in this field. In 1983-84, research continued on basic chemical reactions which affect stratospheric ozone, the acid rain problem, and a general understanding of the troposphere. Significant studies of combustion processes and ion transport properties also were ongoing.

In a major breakthrough, EES scientists became the first in the world to identify and measure ions in the troposphere. In 1983-84, they took their elaborate apparatus to several locations to detect and analyze ground-level samples. Their research will not only cast light upon ion chemistry and its effects, but also help in understanding trace neutral chemistry, which controls such important processes as smog formation and acid rain. Using their sensitive ion measurement technique, they are able to detect certain trace neutral species at levels below one molecule per trillion. The real-time monitoring enables them to detect rapid changes, and the next step will be to measure how ions change as neutral species change.

Related research in kinetic chemistry led to development of a unique method of measuring reactions between two free radicals under atmospheric conditions, using lasers. Although free radicals are very small in number, knowledge of their characteristics is crucial to understanding the chemistry of the atmosphere and combustion. Because they are very unstable, reactive chemicals, they make all these processes go. EES researchers use lasers to create well-controlled and known amounts of free radicals. Other lasers are used to measure the concentrations of radicals and how rapidly these concentrations change over time.

In 1983-84, EES initiated a new research program in molecular sieve zeolites with emphasis on inorganic catalysts and adsorbents, which are areas of high interest to the petroleum, natural gas, petrochemical and specialty chemical industries. The study included the chemical and physical characteristics of zeolite products, their manufacture, and chemical processes that can be enhanced by using them. Work in this area is continuing.



The Station developed this half-scale model of an Aquila drone aircraft.

Communications

In 1984, the application of communications technology to national defense requirements continued to be an important source of sponsored research support. Through several R&D programs funded by the Department of Defense totalling more than $800,000, EES communications engineers investigated the effects of deliberate jamming on complex data communications networks. The Station is developing models to characterize these jamming techniques which will lead to new communications systems more resistant to enemy disruption.

Another program, sponsored by the Air Force, involved extremely high speed transmission of digitized video for airborne battlefield applications. EES engineers analyzed in detail the performance of sophisticated digital communications modulations techniques and sought to develop new communications technologies for stressed electronic environments. This investigation will result in better communications technology and improved strategies for collection of airborne imagery information.

Last year, the Station worked to develop microprocessor technology for advanced signal processing. In this Army-sponsored $1.2-million R&D program, engineers from EES are designing chip microprocessors and associated digital devices, then integrating them with a high speed scanning antenna for air- and ground-based surveillance of radar and communications signals.

Other communications research involved:

- Assessment of various control bus protocols for use with consumer entertainment equipment.
- Command and control networks to support U.S. missile systems.
- High power radio frequency technology for disrupting enemy missile launch capabilities.
- Development of a data base for efficient deployment of military communications systems.

EES has broad analytical capability in communications systems technology, particularly for national defense needs.

This display is part of an interactive computer-assisted project management and scheduling system.

Command and Control

In 1984, EES engineers developed a device to test the total performance of an Energy Monitoring and Control System (EMCS) being purchased by the Navy for various Department of Defense locations. This EMCS consists of a control computer with many sophisticated energy control algorithms which cannot be readily evaluated at one time and place for government acceptance testing. The Station built a device which can simulate a building, with its distinctive heating and air conditioning equipment, and record how long the EMCS performs under a variety of environmental conditions. This hardware was delivered to the Navy's Civil Engineering Laboratory last October.

During the past year, EES researchers also continued to counsel the Army in an ambitious computer development program which will automate much of the U.S. Army's intelligence gathering operations. The Station's role in this MICROFIX program is not strictly advisory. In 1984, EES engineers neared completion of the system's software and conducted system training programs for Army intelligence operators at bases in the United States, Korea and Western Europe.

Another project addressed a command and control problem at U.S. military bases. EES engineers developed software which will allow analysts to determine the optimal locations to site air traffic control radar units. This software incorporates techniques of geoprocessing and radar modeling. In the past, military planners have conducted siting surveys by manual trial and error methods.

Internal development programs also began during the year which involve:

- Networking of dissimilar computational assets and peripheral devices.
- Office automation.
- Knowledge-based (expert) systems for microcomputers.
- A touch-sensitive robotic manipulator which classifies objects or shapes in darkness or murky water.

EES is assisting the Army with its MICROFIX program, which is automating many intelligence gathering operations.

The Station is capable of constructing oriented monomolecular assemblies with a Langmuir-Blodgett trough.

Materials Sciences

In 1983-84, EES continued its studies to identify combinations of ceramic fibers and ceramic matrix materials that will have improved strength and durability under high-temperature conditions. Researchers also investigated ways to fabricate large and complex shapes with such a composite, using sintering techniques. Applications include high-performance vehicles with aerodynamic heating such as missiles, heat engines, fossil energy power stations, and heat exchangers.

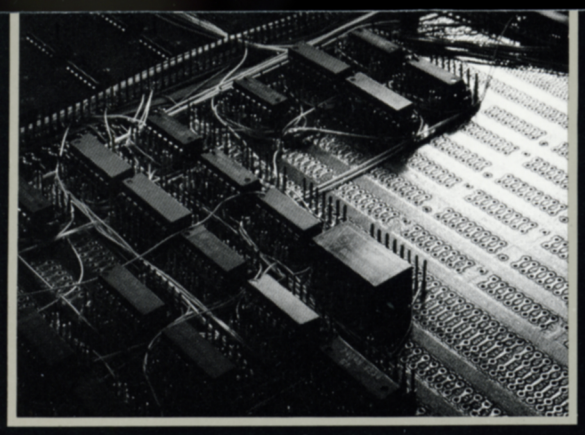
The Station began working on developing thermite processes to synthesize refractory materials, and initial experiments excited a great deal of industrial and military interest. This self-sustaining combustion process is rapid and relatively cheap, allowing the use of inexpensive powdered materials to produce harder refractory materials.

EES began its second year of investigating the effects of acid rain on stone buildings and architectural bronze under contract with the National Park Service. Work continued on developing a field test kit that will enable resources managers to measure and analyze acid rain effects accurately at the sites of historic buildings and monuments. EES personnel also began developing a laboratory test to evaluate the efficacy of several types of protective treatments for stone. The unique sealed tube method involves study of small stone samples under rigidly controlled environmental conditions, using microanalysis techniques. Findings from the study will be incorporated into a comprehensive National Acid Precipitation Assessment Program.

A three-year study to improve the performance of highway bridge protective coatings culminated in 1983-84 with the development of quantified acceptance criteria based on laboratory testing of the effects of ambient conditions and application techniques on paint performance. EES researchers also developed a field-test kit and more accurate field inspection procedures.

Analysis of electronic components has become an increasingly important part of EES's work in materials characterization. Using its extensive collection of analytical instruments, EES researchers continued in 1984 to solve a variety of materials problems for numerous industrial and governmental clients.

This salt fog cabinet accommodates tests of paints and coatings intended to protect steel from corrosion.



Shown here is a prototype of a computer-to-computer interface developed for a nuclear power plant safety monitor simulator.

Computer Applications

The Station reached a significant milestone in 1984 with the installation of computerized safety monitoring equipment in the control rooms of the twin nuclear reactors at Georgia Power Company's Plant Hatch. This Safety Parameter Display System (SPDS) will offer control room operators the option to diagnose a reactor's vital functions automatically.

Working collaboratively with Georgia Tech's School of Nuclear Engineering, the Station is developing an SPDS which may be the most advanced nuclear safety monitoring system is the world. It is the only system of its kind which incorporates military specification designs for durability and one of the few seismically qualified safety monitoring devices in a United States nuclear plant. It is the first milspec computer unit to use 19-inch video display screens for color graphics, and an innovative fiber optics link gives the system dual processing.

EES' involvement in the automation of nuclear safety monitoring will continue at Plant Hatch for the foreseeable future. Station researchers hope to develop a system which monitors the entire plant rather than its essential functions.

In another long-term program, EES began to develop a continental telecommunications information network for the U.S. Army Forces Command (FORSCOM) at Fort McPherson, Georgia. The network will provide an automatic means of handling an accounting and information management system which coordinates all budgetary matters for the Army involving personnel training and construction projects. During 1984, EES engineers completed feasibility and design studies, then assembled a limited capability system which will serve as a foundation for the network.

Other notable computer applications research involved:

- Autonomous navigation systems.
- Target identification through artificial intelligence.
- Geoprocessing with LANDSAT data.
- Enhancement of an advanced telephone switching network.

Station engineers installed this simulator of a Safety Parameter Device System at Georgia Power Company's Plant Hatch.

Field office engineers help a Georgia firm install an industrial robot.

Assistance to Industry

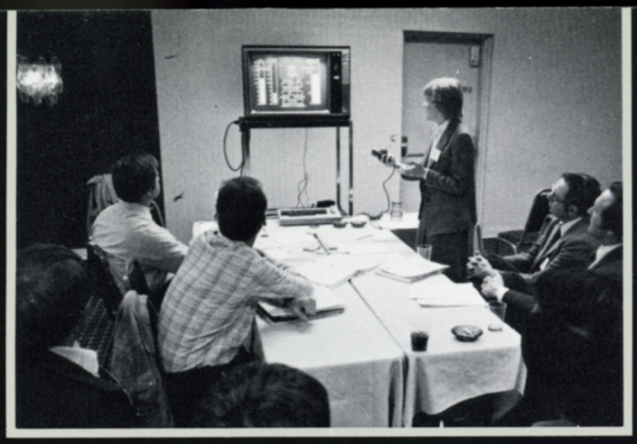
In 1983-84, EES continued to provide a myriad of services to hundreds of industries in Georgia and the Southeast. Most of them were small or struggling companies requiring short-term assistance or information. Larger firms or those requiring extensive assistance either contracted with Georgia Tech for specialized work or were referred to consulting engineering firms.

The engineering staff of the *Industrial Extension Division* (IED), through its eight field offices in Albany, Augusta, Carrollton, Douglas, Gainesville, Macon, Rome and Savannah, visited approximately 600 Georgia companies in 1983-84. The division provided technical assistance to 300 of these firms and answered some 900 information requests. In dozens of instances, IED served as the link between industry and campus experts in both EES and the Georgia Tech academic units. Economic development efforts included "Targeting Industries" studies for several Georgia communities. These studies surveyed the areas' strengths and weaknesses for attracting industry and targeted the industries best suited to them, using a computer-assisted decision technique. During the year, the Georgia legislature authorized funding to open four more field offices in late 1984 — in Brunswick, Columbus, Dublin and Madison.

In FY 1984, EES engineers completed in-plant energy audits for 90 industries under two complementary programs: the *Industrial Energy Extension Service* (IEES), sponsored by the Georgia Office of Energy Resources, and the *Energy Analysis and Diagnostic Center* (EADC), sponsored by the University City Science Center and the U.S. Department of Energy. The IEES program also included industrial energy workshops attended by some 150 persons, plus publication of technical briefs and a quarterly newsletter.

Another sharply focused industrial assistance effort was conducted by the *Environmental Health and Safety Division.* During 1983-84, its certified professionals provided on-site technical assistance or off-site analytical services (accredited by the American Industrial Hygiene Association) to about 600 Georgia companies. An equal number of business representatives from as far away as Hawaii and Canada attended some 16 continu-

Field office specialists helped a Columbus welding company introduce computers into its operation.



This energy conservation workshop described how computer graphics can be used in boiler maintenance.

An Atlanta area sewing firm received on-site assistance from the Station which helped the company upgrade productivity.

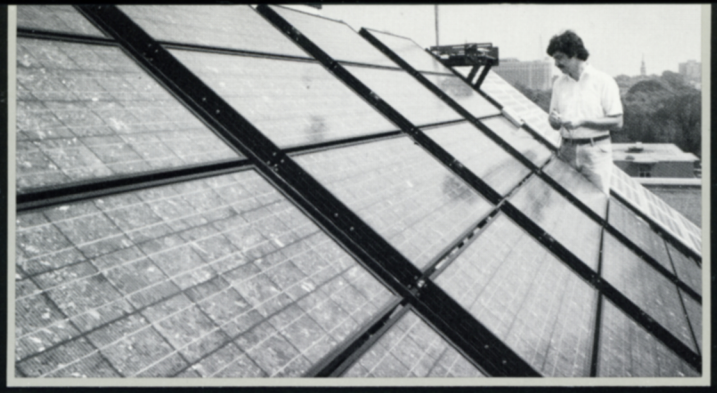
ing education courses offered by the Division. The technical assistance and courses covered a wide range of issues, such as general occupational safety and health, hazardous/industrial waste, asbestos, noise, toxicology, ergonomics, and construction hazards. A highlight of the year was initiation of an Environmental Protection Agency-sponsored pilot program to assist small Georgia businesses in meeting federal and state hazardous waste management regulations.

Under a program funded by the U.S. Department of Commerce since 1978, the *Southeastern Trade Adjustment Assistance Center* (TAAC) continued to provide technical assistance to regional businesses adversely affected by import competition. FY 1984 saw a substantial increase in the demand for TAAC services and considerable diversification in the types of industries assisted. The proportion of textile and apparel industries in the program dropped to 30 percent with a shift to machinery and other capital goods industries.

EES's minority business development efforts enjoyed continued success under two programs sponsored by the Minority Business Development Agency. The *Technology Utilization and Commercialization Center* (TUCC) completed its sixth year of helping minority inventors and entrepreneurs and minority-owned firms bring technology-related products to the marketplace. During the year, TUCC evaluated more than 80 innovations and handled over 100 requests related to new product ideas and inventions, primarily in eight southern states.

In its second year of operation, the *Rural Assistance Program* (RAP) provided in-depth assistance to some 60 minority-owned firms in five southeastern states. Another 30 companies received less intensive aid. These services included feasibility studies, market analysis, direct management and technical assistance, developmental services, and brokering assistance in contract procurement and financing.

The *Industrial Education Department* continued to be in demand, presenting nearly 200 courses to more than 4,000 students at some 70 aerospace, electronic and textile plants throughout Georgia. These courses comprised both general and customized in-plant technical training and management development services, as well as seminars, workshops and conferences.



EES is helping to enhance photovoltaic solar cells as a supplemental source of residential electric power.

Energy Alternatives

Last year, EES maintained its position as one of the leading university-based research organizations in energy alternatives R&D, fielding a program noted not only for its excellence, but also for the breadth and variety of its activities. Areas of interest included solar thermal, photovoltaics, biomass, and conservation.

The Solar Thermal Advanced Research Center continued research in high-temperature materials for advanced solar thermal conversion systems, solar blind pyrometry, and a direct solar flux reactor for converting solar thermal energy into chemicals and fuels.

A project sponsored by the Solar Energy Research Institute involved assessing the technical feasibility of using molten salt as an efficient means of transferring the heat from the sun to industrial applications. EES engineers designed and fabricated the experimental solar hardware for forthcoming experiments to characterize the behavior of a eutectic mixture of carbonate salts when heated by the sun.

EES completed its design and analysis tasks for Advanco Corporation on a solar electric power generation module coupling a parabolic dish with a Stirling heat engine. The module is being tested by private industry as part of a utility system.

In the second year of its residential photovoltaics study, the Station concentrated on investigating the problems involved in feeding excess electricity from solar cells back into electric utility power grids. EES engineers developed techniques to measure the impedance and harmonics generated on live utility lines.

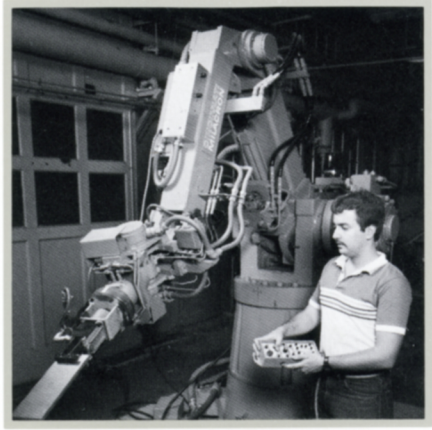
In the biomass field, research continued on the following:

- Further development of a thermochemical process for reusing toxic effluents produced during biomass gasification.
- Invention of a new binding technology to create a cellulosic formed fuel from agricultural and forest waste products.
- Refinement of an advanced "entrained flow" pyrolysis system to produce liquid and gaseous fuels from wood products.

EES began collaboration with Omnimax, Inc. to develop a thermoelectric generator to produce direct current electricity from industrial waste heat, with Omnimax providing the conceptual basis and EES developing a large-scale prototype.

Engineers are working to develop a new technique of cleaning wood gasification effluents.

EES engineers use this vision system to process tactile sensing information.



In 1984, EES began robotics programs for the Postal Service and Warner Robins Air Logistics Center.

Productivity

The Georgia Productivity Center, created and supported by the Georgia legislature, completed its ninth year of activity in 1984. Field service engineers helped 52 small- and medium-sized industries in Georgia improve their productivity through assistance on such problems as productivity measurement, material handling, production methods and flow, inventory control, and human factors.

Educational activities of the Center included seminars on productivity management and continued publication of a bimonthly newsletter. A typical technology research project focused on electric-based processes that would upgrade productivity in the textile industry.

Realizing the importance of manufacturing technology to industrial productivity and recognizing that it is a multidisciplinary process requiring a broad base of expertise, the Station established a Manufacturing Technology Programs Office in 1983-84. This office was charged with coordinating the wide variety of efforts among the EES laboratories.

A campus-wide survey revealed that all major research units in EES offered knowledge, experience and skills in one or more of the following key disciplines: artificial intelligence, computer-aided engineering design, sensor technology, robotics, computer-integrated manufacturing, computer-assisted decision support systems, software engineering, and human/computer interactions. The office also began investigating how EES could take this know-how, most of which was developed by defense contract work, and transfer it to the manufacturing sector.

EES participated in several projects involving robotics, containerization and sensors through Georgia Tech's Material Handling Research Center during 1983-84. It also collaborated with the College of Engineering in developing a Computer Integrated Manufacturing Systems Program.

Robotics work during the year included:

- Assistance to the U.S. Postal Service in automated sorting and processing of irregular parcels, using tactile sensors and laser guidance for industrial robots.
- Recommendations for robotics applications in the warehousing and distribution operations of the Warner Robins Air Logistics Center.

Station engineers are helping the Philippines use wood fuel to generate electricity.

U.S.-based industrial training programs were part of an EES effort to upgrade industrial productivity in Egypt.

International Development

In 1983-84, EES began a new project to assist the National Electrification Administration of the Philippines in developing that island nation's capacity to generate electricity from wood fuel. The plan involves cultivating the extremely fast-growing giant *ipil-ipil* trees on tree farms and harvesting them to fuel 3-5 megawatt power plants.

EES reached the halfway mark in a two-year program to help Central American industry conserve energy. Resident Station staff and short-term consultants provided direct technical assistance to private companies. They also trained local engineers to perform energy audits and carry out conservation measures without need for dependence on EES expertise.

In the northern African nation of Sudan, the Station resident staff chalked up several accomplishments in a long-term project to adapt and introduce renewable energy technologies to rural areas. They began small plantings of rapidly growing and hardy trees. They also produced and tested prototype charcoal stoves. To enable the Sudanese to take over the project, eight Sudanese staff members began graduate-level training in renewable energy.

The multi-year project to establish an industrial extension service for Egypt got into full swing. Thirty-six industrial plants were surveyed in a series of diagnostic visits, and some 250 information requests were handled. Short-term consultants were provided for the textile and garment industries and in the areas of maintenance management, quality control, and materials handling. Tours of American industry were arranged for three groups of approximately 20 Egyptian industrialists to learn about new processes as well as export and joint venture opportunities.

Other notable activities in 1984 included:

- Design of a new low-cost, easily fabricated hand water pump and a latrine for village use, and installation for field testing in the Dominican Republic.
- Provision of custom-designed three- to five-month training programs for groups from developing nations.
- Assistance to the Norwegian Textile Manufacturers Association in developing a 10-year strategic plan to stabilize their industry.

Machinery evaluations are part of EES' program of assistance for the state's agricultural industry.

EES is helping to turn a large Georgia dairy operation into an "energy integrated farm."

Agricultural Research

After two years of study and design by EES engineers, Georgia's Energy Integrated Dairy Farm became a reality in 1983-84. The integrated system centers on an anaerobic digester which converts cow manure into methane-rich "biogas." The biogas fuels an engine which generates electricity for milking machines and refrigeration. The waste heat from the engine, in turn, heats the digester. Dried separated solids from the process are recycled as animal bedding, and the liquid effluent is used as fertilizer for the field crops, which are grown for cattle fodder.

In 1984, EES entered its second decade of research and service to Georgia's largest agri-business — the poultry industry. The program is funded largely by the Georgia legislature and conducted in cooperation with the Georgia Poultry Federation. Among the continuing advances made in poultry technology were the following:

- Work toward development of practical, low-cost sensor technology to measure ammonia and relative humidity levels in growout houses.
- Development of a preventive and predictive maintenance system to reduce the major problem of unscheduled outages of electrical equipment. The program is aimed at cutting operational costs and improving the overall productivity of poultry processing plants.
- Progress toward development of alternative handling and disposal methods for the rapidly growing volume of processing sludge. Research efforts focused on finding ways to make the sludge easier to render.

Two previously developed technologies made further progress toward commercialization in 1983-84. The microprocessor-based information system for reporting condemnations and contaminations identified during inspection attracted substantial interest among poultry processors. The software was rewritten, and EES began looking for a suitable manufacturer to license the software and design concept. In addition, the unique noise abatement panels designed by EES engineers were manufactured for commercial distribution by two national companies and put to use in a number of processing plants.

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