1975 Annual Report
Engineering Experiment Station

Georgia Institute of Technology • Atlanta, Georgia

1975 Annual Report
The Engineering Experiment Station

Observations of the Director

A Year of Actions to Promote Growth

The Engineering Experiment Station (EES) is a client-oriented research center supported primarily by Federal and industrial contracts. The balance of funding comes from a State appropriation to encourage the development of Georgia. EES operated under a legislative charter that includes research and service for the benefit of Georgia's people, its industry and its economic development, and assistance to national programs of science, technology and preparedness.

The Station serves the Nation, the State, and the Georgia Institute of Technology through advanced technological research and development programs. It serves the State by bringing in dollars to Georgia directly through contracts, through attracting industry, through developing new industries, and through creating new jobs in existing industries.

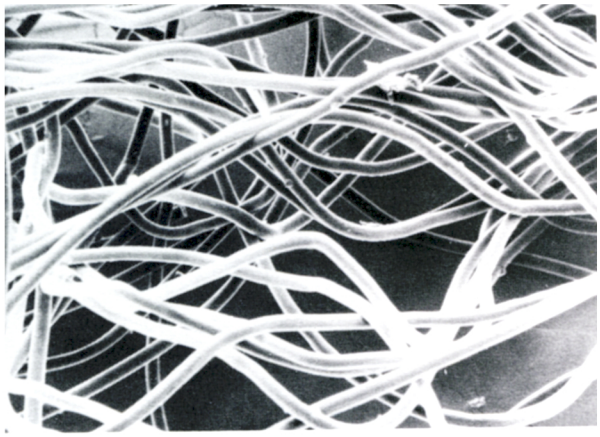
During FY 75 emphasis was placed on obtaining an increased level of financial support that will be of benefit to Georgia. Sponsored personal services is a good indicator of support brought into Georgia through research. This year our sponsored personal services increased 11 percent, and our goal for the next fiscal year is a 25-percent increase. This year, considerable emphasis has been placed on planning for such growth, including internal reallocation of space and facilities, and we have hired several well-qualified persons to provide leadership in planned growth areas.

As an example of growth opportunities, there is increasing national awareness of the important role that research and development must play in attaining conservation of energy resources, improving waste conversion processes, and increasing productivity. It is apparent that in coming years a significant portion of the Federal research and development budget will be directed toward solution of these energy-related problems. Consequently, we are planning our investments of resources to capitalize on these opportunities.

In an effort to develop an EES-based productivity program for Georgia, relations have been established with a number of trade associations in the rug and carpet, lumber, poultry, and granite industries. In recognition of our productivity program, the General Assembly of Georgia passed a resolution in April designating EES as the Georgia Productivity Center. The resolution stressed the role of technology in efforts to improve the productivity of business and government and the need for a designated group within state government to coordinate relevant Federally-funded programs. The EES staff also has assisted Senator Sam Nunn in preparing legislation for a National Productivity Center after the pattern of the Georgia model.

The Energy and Materials Technology Division was formed in May 1975 to better manage our energy-related research. As a consequence of continued growth, the Technology Applications Group and the EES Productivity Program are being administratively combined effective July 1. The consolidated effort was named the Productivity/Technology Applications Group.

M. W. Long
Director
Engineering Experiment Station



Research Volume and Station Staff

Total expenditures included in the EES budget amounted to $8,541,290. The funds are obtained from contracts handled by the Georgia Tech Research Institute, from the State appropriation received through the Board of Regents, and from several smaller sources. The income exclusive of that from the Board of Regents equaled $6,422,905, and State funding received through the Board of Regents equaled $2,204,000. One useful measure of research and service activities is sponsored personal services and this reached an all-time peak. For FY 75 sponsored personal services amounted to $3.1 million, up from $2.8 million the previous year.

On May 31, 1975, there were 328 full-time employees (of which 212 were professional staff members) and 242 part-time employees. The number of part-time employees included 139 graduate and undergraduate students on that date. Student employment represents a significant contribution that EES makes because jobs are provided which offer valuable research experience for both undergraduate and graduate students.

The total for contract awards during FY 75 was $7.1 million, also a record high. For FY 74 new contract awards totaled only $4.7 million as compared with $5.3 million for FY 73. The timing on proposal reviews and negotiations for contracts with the Government now appears back to normal. Part of the difference between FY 75 and FY 74 was probably due to awards being delayed; however, there is a definite growth trend.

Contributions to Georgia and the Nation

Each year the research and service activities of EES contribute to the creation or preservation of thousands of jobs in Georgia. Economic analyses reveal that the impact of EES and its spin-off activities amounts to approximately $100 million annually, and the State tax revenues generated by this economic activity are over $4 million.

In continuing its established concern with the conversion of wastes into fuels, the importance of which has been re-emphasized by the national fuel crisis, the EES has increased the thrust of its efforts toward other energy-related projects. Programs are now under development in the areas of energy and environments, solar energy, and productivity improvements for industry and government in Georgia. Other new program development efforts of national significance are in the fields of solid-state materials and devices, guidance and sensor technology, infrared and optics technology, and communications systems.

Contract support for research in the *Applied Sciences Department* accelerated during the final months of FY 75. Approximately 40 percent of the new awards and 50 percent of the outstanding proposals are in energy-related research. Substantial progress continued to be made in solar energy research particularly in the areas of high temperature applications for electrical power generation and the utilization and design of solar test facilities. EES continues its close working relationship with the Solar Energy Laboratory at Odeillo-Font Romeu in France, solar research at the University of Genoa, Italy, and the White Sands Solar Furnace in New Mexico. Studies are continuing with Martin Marietta under NSF/ERDA sponsorship on the design of a solar energy steam boiler and super heater for the generation of electrical power. A study is also underway to examine the feasibility and suitability of the coastal area of Georgia for use

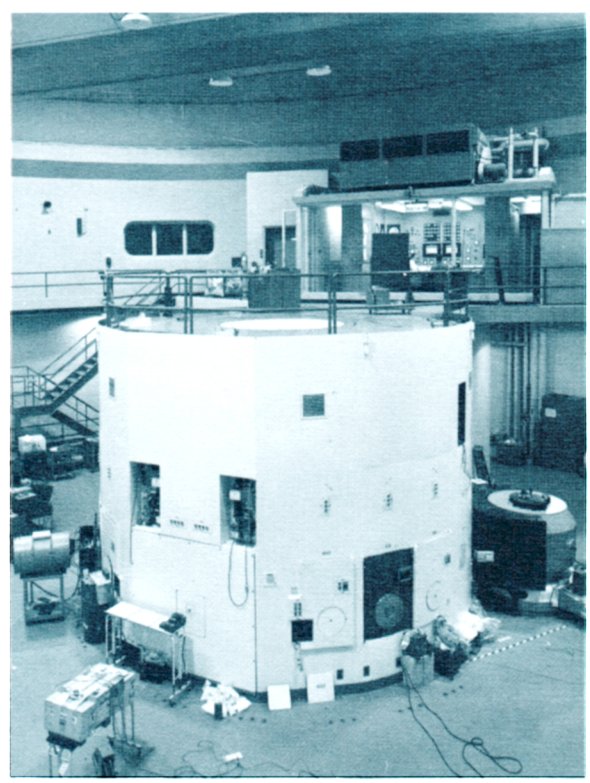
as a solar energy research and development center. Work is being performed for the Federal Energy Administration to monitor the industrial energy conservation efforts of selected energy-intensive industries such as chemical, petrochemical, steel, aluminum, paper, and cement.

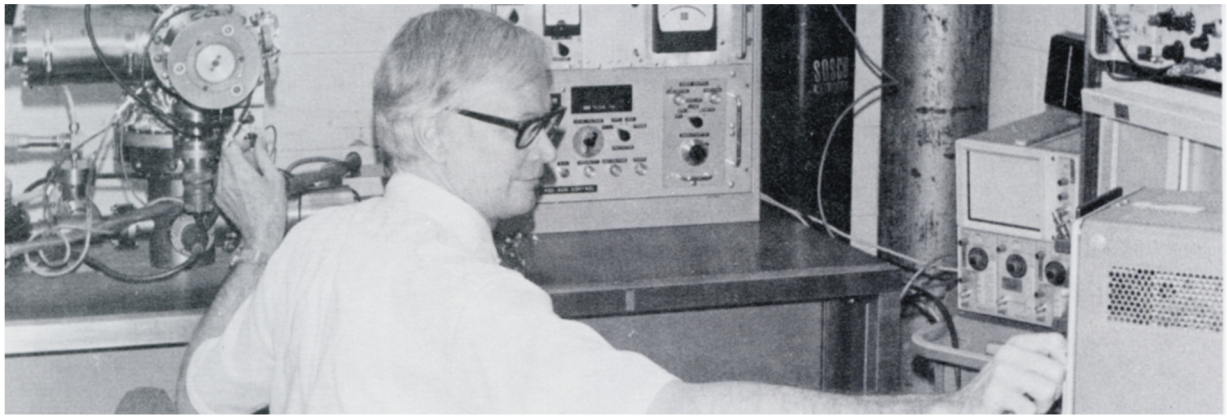
A major research program is being conducted for the Air Force Avionics Laboratory in the field of microwave devices and circuitry which involved chip-level power combining for direct microwave signal generation. Other active programs include research in semiconductor materials and reliability and failure analysis of electrical components. The high performance requirements of modern missile systems dictate the employment of intricate materials combinations for electronic controls, structural members, and propulsion.

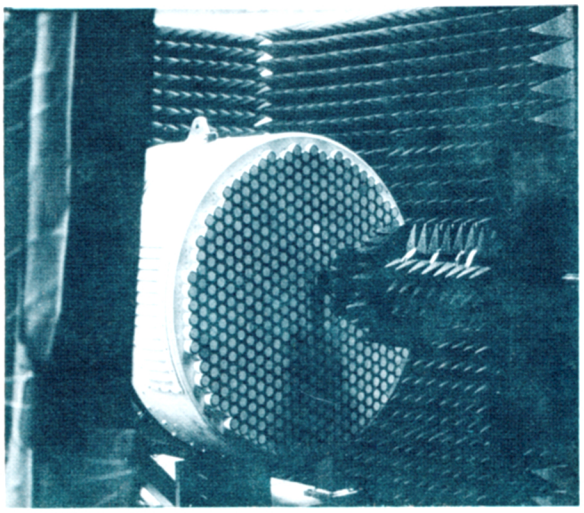
Investigations continue in the environmental and life sciences. One project sponsored by the Office of Water Resources Research is being conducted to investigate the cause of trout kills in hatcheries where water is obtained from deep lakes.

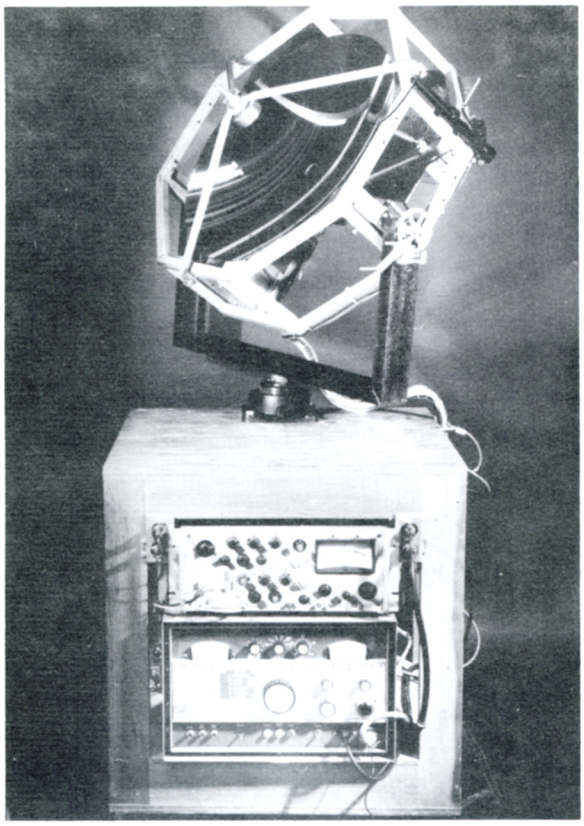
The Analytical Instrumentation Laboratory continued its work on a variety of projects in behalf of Georgia's business and industry. Research included examinations of streaking in carpet yarn, air filtering for asbestos, rocket exhausts, glass materials, paint pigments, wear in aircraft engines, textile material analyses, and measurement of noise in industrial plants.

There has been significant growth in the *Systems and Techniques Department* during the year. Sponsored research has increased with major funding continuing to be from numerous agencies of the Federal Government. Also, there are sub-contracts from other Government contractors and various projects for industry and the State of Georgia. Typical areas of electronics research include antennas, radar systems, electromagnetic compatibility, radar reflectivity measurements and analysis, electromagnetic properties of materials, communications, radiolocation/direction finding, coherent optics, guidance and control, systems analysis, and biomedical electronics. Approximately 130 sponsored research programs were active in these fields during the year.





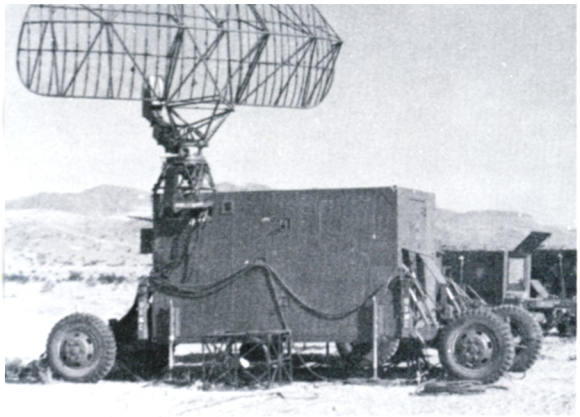


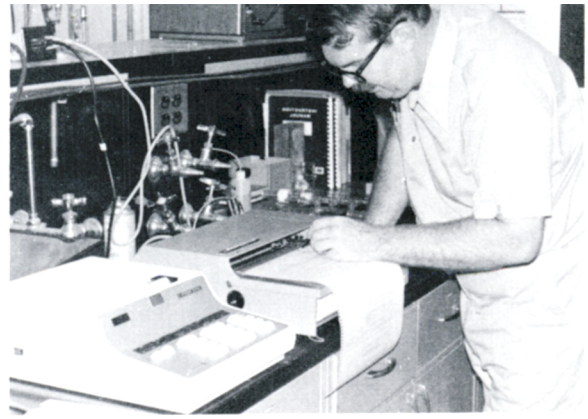


There continues to be an active research program in digital communications including bit-error-rate degradation in hard limiting transponders, allocation of implementation losses among subsystems, and analysis of offset phase-shift-keying. Significant work is being done in electromagnetic compatibility research related to systems used in air traffic control for the FAA and biomedical applications such as cardiac pacemaker performance.

Our radar research and development continues to be strong and growing. There have been major efforts in detection of target signatures, developing stationary target indication techniques, and in radar environment simulation. Work has continued in systems analysis such as microwave tube reliability and manpower projection studies, and important research has been performed in electronic countermeasures technology. We continue to be a leading developer of an innovative near field technique for determining the microwave fields radiated by antennas or scattered by radar targets. Valuable research has progressed in the biomedical technical investigations of the effectiveness of microwave thawing of human granulocytes that were frozen for preservation and storage.

Substantial programs are continuing for the Naval Electronics Systems Command, including a real-time detectability analyzer and related prediction modeling. Radars for detecting projectiles and locating hostile weapons, analysis of tracking and command guidance radars, and the design development and fabrication of antennas for the armed services are all active programs. Radar field measurements as a part of radar system development and for the purpose of acquiring basic data on the properties of land and sea clutter and of radar targets continues to be an active area of research as does the prediction, measurement, and control of the radar cross-section of targets. Mechanical R&D work continues on equipment development for automating the handling of poultry processing,





a program being sponsored by the Georgia Department of Agriculture.

There have been new programs involving testing and analysis of RF missile seeker systems, and studies of high-power submillimeter wave source applications. NASA continued to sponsor our investigations of optical and digital processing techniques for earth observation imagery. A program with NASA involves antenna development for the SERT-C Satellite, and another project involves development of an experimental severe weather and tornado detection and tracking system.

Contract support for the *Industrial Development Division* reached a 19-year peak during FY 75. For the eleventh consecutive year the Economic Development Administration provided a management and technical assistance grant for businesses and industry in Georgia. Assistance was provided to the Farmers Home Administration of the USDA with evaluation and preparation of applications for business loans. The Georgia Department of Community Development extended the contract to study Georgia kaolin as a source of alumina. Assistance was provided to a number of outside industries in selecting facilities in Georgia for new locations, and work continued with the Coastal Plains Regional Commission on the housing project which has resulted in the building of several hundred low-cost homes, apartments and condominiums in South Georgia. The Industrial Development Division continues to be a national leader in the field of international development with seven different projects in eight developing countries.

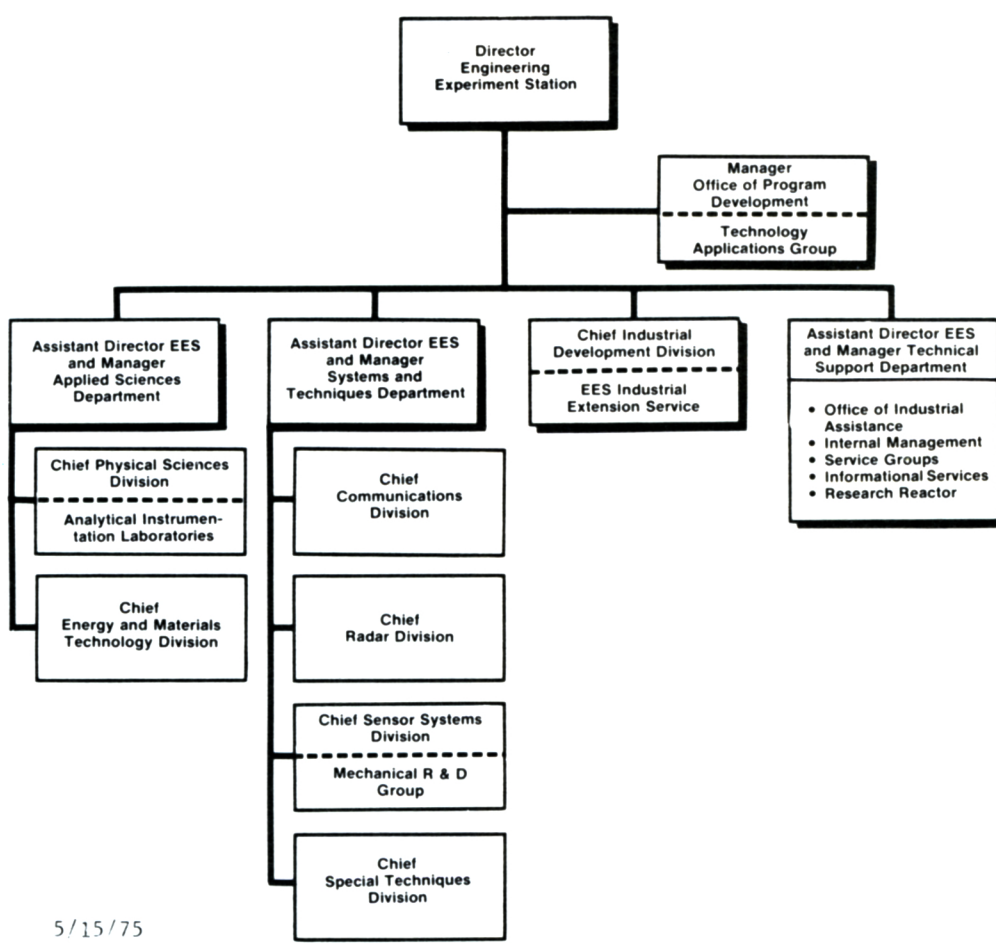
The *Technology Applications Group* maintained primary thrusts in waste utilization, industrial chemistry, minerals economics and beneficiation, and in industrial energy conservation. The growth in level of sponsored research that occurred is largely attributable to directing efforts toward energy-related projects in conservation technology and conversion of wastes into fuels. Sponsored research included projects involving cotton gin wastes, poultry wastes, and extensive processing of municipal wastes. A 25-ton/day pilot plant was placed in operation and was used to successfully process hundreds of tons of shredded municipal wastes. A significant quantity of energy-related work was performed to aid Georgia business and industry in coping with their energy problems. Approximately 60 plant visits were made to establish energy profiles and identify energy-consumption problems. These were followed by a series of state-wide management conferences and technical workshops.

EES Area Offices

Industrial Research and Extension

EES provides assistance in short-term problem solving to Georgia industry through our seven state-wide offices of the Industrial Extension Service and through the Office of Industrial Assistance at EES in Atlanta. It is estimated that about 2,000 industrial contacts of all types occurred during the year. The types of assistance provided include product and process development, production layout and controls, equipment location, energy conservation, and technical information and assistance on matters relating to environmental quality, health, and safety. Where appropriate, industrial requests were referred to consulting engineers or testing laboratories.

Organization of the Engineering Experiment Station



Research Operations

Applied Sciences Department

Overview

The Applied Sciences Department has conducted research during the year in the following major areas: energy management and conservation; solar energy; solid state electronics; microwave devices, materials, and circuitry; failure analysis of solid state circuits and devices; analytical and physical characterizations of materials; surface characterization of materials; micromechanical properties of materials; characterization of materials of biological (tooth enamel), synthetic and mineral origin by x-ray and neutron diffraction techniques; radomes (slip-cast fused silica and reaction sintered silicon nitride); water and air quality; waste management and treatment; chlorination of water; and technology assessment and transfer.

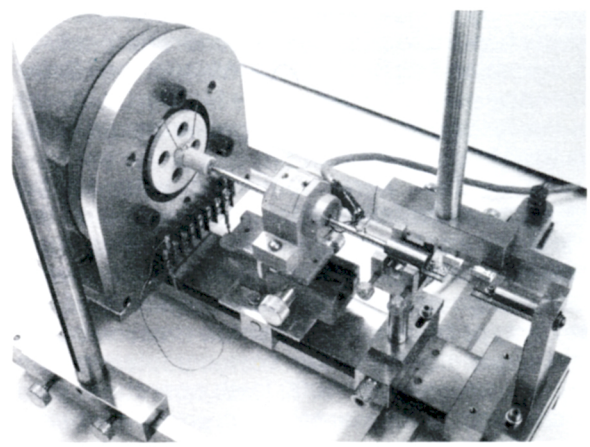
The Department prepared and conducted specific growth plans to strengthen and enlarge its research activities in solid state materials and devices (including failure analysis), in the research and applications of solar energy, and in energy and environmental management and conservation.

Contracts have been received during the year from the following agencies:

- Federal Energy Administration (FEA)
- National Science Foundation (NSF)
- Energy Research and Development Administration (ERDA)
- Department of Defense (DoD)
- National Institute of Health (NIH)
- State Energy Office
- Coastal Plains Planning and Development Commission
- various industrial firms

Of the $1.1 million of new contract awards received during the year, DoD awards constituted about 26%, industrial programs, 12%, and all others, 62%. Approximately 40% of new awards and 50% of outstanding proposals are in energy-related research.

The Energy and Materials Technology Division (EMTD) was formed in May 1975, as a new Division of ASD. Effective with the formation of EMTD, the High Temperature Materials and the Nuclear and Biological Sciences Divisions were dissolved. This new organizational structure is expected to improve efficiency of operations and administration and will better reflect the character of ASD's current research efforts.



Gordon R. Harrison
Assistant Director for
Applied Sciences

Solar Energy

The Department has continued to make substantial progress in solar energy research particularly in the areas of high temperature applications for electrical power generation and in the utilization and design of solar test facilities. The staff is involved on an international basis with continued close working relationship with the 1000 kw CNRS solar furnace operation in France and Professor Francia's solar (130 kw) boiler facilities at the University of Genoa, Genoa, Italy. The staff has also conducted a cross-calibration study program and analysis of the White Sands Solar Furnace in New Mexico. This facility (at 35 kw) is the largest solar furnace presently available in the U.S.

Studies were continued with Martin Marietta under NSF/ERDA sponsorship on the design of a solar energy steam boiler and super heater for the generation of electrical power. The design and thermal stress analysis of the cavity type bench model central receiver boiler and super heater tubes were completed. The boiler (designed for 1000 kwth operation) with associated instrumentation is presently being fabricated.

A study is presently underway to examine the feasibility and suitability of the coastal area region of Georgia for use as a solar energy research and development center. This program is under sponsorship of the Coastal area Planning and Development Commission.

Participation is expected to be underway early in FY 76 for a proof of concept study of a large solar energy electric power generation plant and for the design and specifications for a 5-MWth U.S. solar test facility. A proposal has been submitted to ERDA for development and evaluation of a 400 kWth solar steam generating plant and central receiver type solar thermal test facility on the Georgia Tech campus. In addition, a strong thrust has been generated for the location of a national solar test facility and laboratory in the State.

Energy Management and Conservation

A program is being conducted for the Federal Energy Administration for monitoring industrial energy conservation activities. The study is focused on the following energy intensive industries: chemical and petrochemicals, petroleum refining, steel, aluminum, paper, cement, copper, glass, frozen foods and vegetables, and meat packing.

The program involves the identification and categorization of industrial processes that appear to have energy conservation potential which should be addressed in the monitoring program, the preparation of procedures for energy conservation reporting, the preparation of a system for evaluating the collected data and the preparation of a computer program or other suitable system to support the monitoring program.

A project titled, "A Study of Power System Options for the Southeastern United States," sponsored by the National Science Foundation, was initiated in April. The project examines, from a regional perspective, potential opportunities for increasing the efficiency and lowering the cost of electrical power generation and transmission.

A program was initiated in May with the State Energy Office to collect and document a complete State energy audit identifying energy supplies, distribution, and utilization in the State. The program is also identifying in-state energy resources, their abundance, and status of present and future availability with development priorities. Energy conservation priorities and impact will also be assessed.

Solid State Materials and Devices

Microwave Devices and Circuitry. A major program in this area is supported by the Air Force Avionics Laboratory for chip level power combining for direct microwave signal generation.

The primary goal of this effort is to combine the microwave power outputs of IMPATT direct signal generators at the diode chip level. Experiments involving the series and parallel interconnection of p^+nn^+ and double drift silicon devices and gallium arsenide Read devices are in progress.

Numerous series chip configurations using up to ten separate chips have been tested using Type II-A diamond as a heat spreader and electrical insulator. At low power levels, most of the circuits tested give excellent results. As higher power levels are approached, however, the nonlinear properties of the devices result in serious parametric instabilities over and above those often encountered with similar individual devices. The onset of parametric instabilities limits the maximum power output of such configurations. A major goal of this ongoing work is to apply resistive-mode suppression techniques to the solution of this problem.

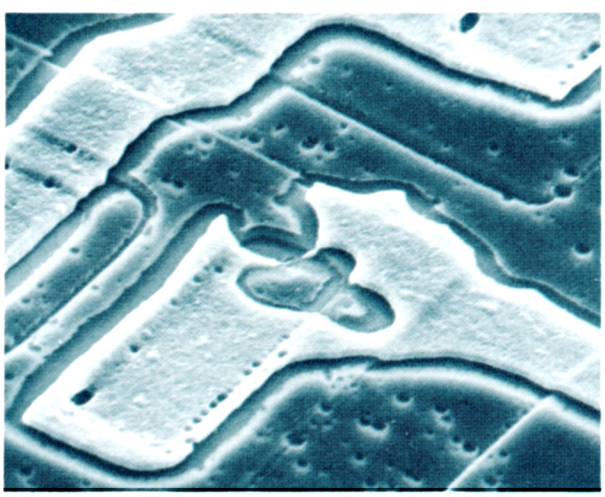
The long-range objective of this work is to combine high-efficiency, high-power, Read-type gallium arsenide and/or silicon double-drift device chips to demonstrate CW power output of 30 Watts or more and pulsed output of 100 Watts.

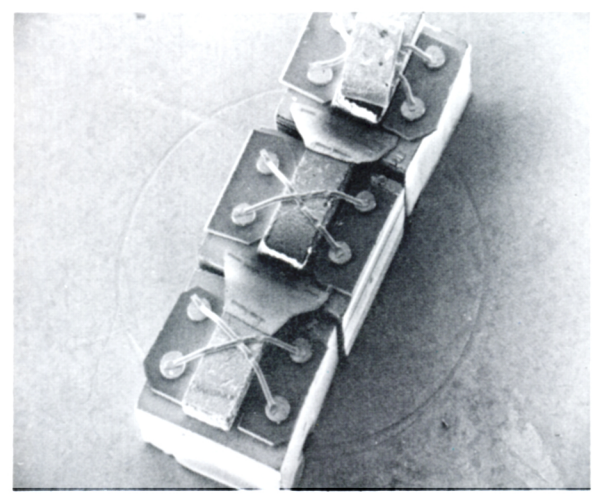
The purpose of a similar program involving TRAPATT devices (program supported by the ONR/NRL) is to investigate the series interconnection of TRAPATT diodes on insulating substrates in order to achieve higher power levels from high-efficiency, solid-state microwave signal generation. The primary objective is to determine the necessary conditions for combining several TRAPATT devices in a configuration thermally suitable for long-pulse and/or CW operation without degrading the microwave performance.

Semiconductor Materials. The semiconductor and microelectronics laboratory is supportive to many programs underway. The laboratory is processing materials for device evaluation and is fabricating and evaluating (failure analysis) integrated circuits from logic, digital configurations through 35-GHz microwave circuits. A GaAs epitaxial materials reactor is nearing completion and should be operational during FY 76. This facility will be utilized to advance state-of-the-art technology in GaAs and related semiconductor compounds.

Reliability and Failure Analysis of Electronic Components. A recently funded program with the U.S. Army Missile Command is designed to evaluate the reliability factors that may be most significant for electronic devices in a storage environment. The critical study includes a reexamination of known facts on the performance and degradation of particular devices, the results of screening and accelerated life tests, and the identification of failure mechanisms.

A significant achievement during the year to the failure analysis and reliability activities has been the generation of techniques to unpackage microelectronic circuits and devices with such precision that circuit quality can be carefully and completely examined and analyzed. Over 200 such circuits have been examined for circuit quality, bond strengths, and process flaws, etc., for a quality assurance program.





Materials Research

Characterization Studies. The Staff of the Crystal Physics Branch (CPB) continued their multifaceted investigations of the effects of atomic substitutions and impurities on calcium-phosphate (apatitic) materials of biological (tooth enamel), synthetic, and mineral origin. Understanding, concomitant to control, of the underlying atomic-scale mechanisms of the effects are sought. Precision X-ray single crystal structure refinement and X-ray and neutron powder diffraction are the principal techniques used in conjunction with other physical and chemical methods as needed. The high and highly anisotropic character of the dielectric properties of chlorapatite were explained by a defect mechanism. $CaCl_2$- deficient chlorapatite was prepared in single crystal form and studied for its possible analogy with the calcium-deficient "hydroxyapatite" of bones and teeth. Structural effects of the deficiency were found to include, somewhat unexpectedly, removal of calcium remote from the chlorine as well as that nearby it.

A major emphasis has been focused on powder diffraction studies using computer procedures for data handling and analyses. A new analysis technique, pattern-fitting structure refinement (PFSR), plus improvements in X-ray powder diffractometry has produced a factor of 10 improvement in detectability and accuracy.

The Surface Science Group has continued to emphasize the application of electron and ion beam scanning techniques to elucidate the chemical and morphological nature of exposed surfaces. When scanning electron microscopy is combined with electron spectroscopy, a new dimension is added to the highly sensitive analytical method of electron spectroscopy. This dimension is spatial resolution, i.e., being able to determine the precise location from which analytical signals are being derived.

During the past year instrumentation has been developed which detects the chemical constituents, in fractions of a surface monolayer sensitivity, from an irradiated area of 20 microns. The 50-micron-diameter scanning electron beam enables electron micrographs of surface features to be obtained up to a useful magnification of about 1000 diameters.

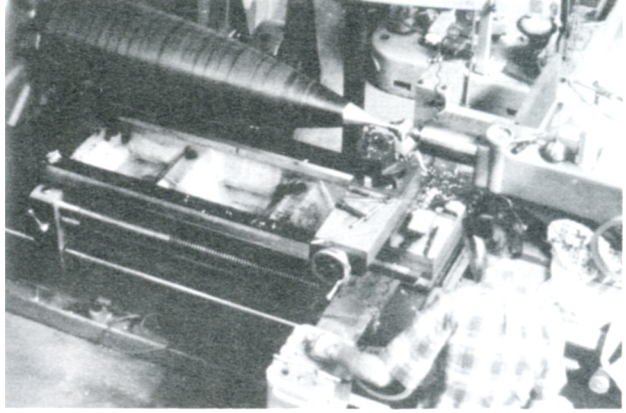
This methodology, as well as the more conventional electron microscopic techniques, is being applied to a variety of problems, which range from semiconductor fabrication and reliability studies to the identification of micro-constituents in biological thin sections.

The staff of the Analytical Instrumentation Laboratories has performed analytical studies on 109 separate projects during the year. The activity was concentrated in the materials and physical sciences and included the following:

- Evaluation of asbestiform minerals in mining water effluent
- Examination of commercial pigments for presence of asbestiform minerals
- Studies of fire-retardant fabrics
- Studies of papers and paper fillers
- Metallurgical failure analysis of aircraft structures
- Dye adsorption on textile fibers
- Causes of streaking in carpet stock
- Analysis of particulate air contaminants
- X-ray diffraction studies of hydrated Portland cement
- Qualification of hard metal coatings on meat saws
- Evaluation of solid state devices

Biological investigations included the following:

- X-ray diffraction studies of lung tissue
- TEM studies of chromosomes
- SEM examination of various fungi
- SEM examination of marine organisms
- SEM study of hair and body parasites



Radomes and Related Materials

Research on slip-cast fused silica and silicon nitride as materials for radome applications has continued during the year. Investigations have included fabrication and forming techniques, evaluation of raw materials, variation of processing parameters, examination of physical and intrinsic properties, and the evaluation of electrical (microwave) characteristics.

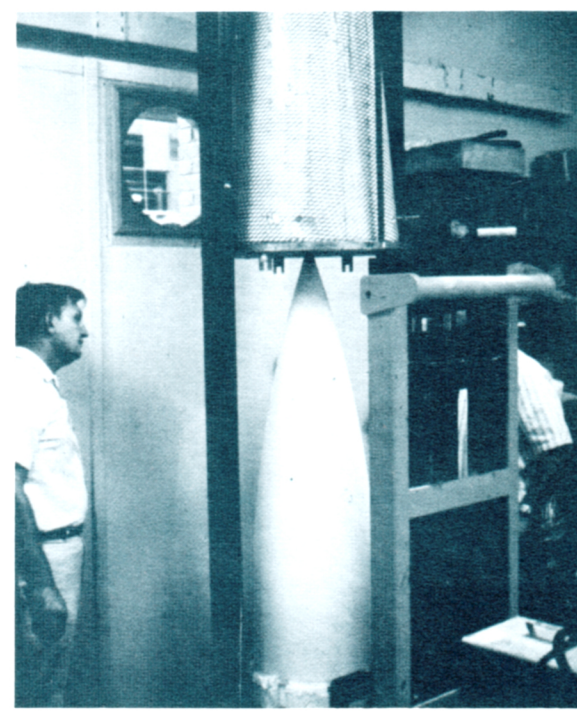
Aggregate casting of fused silica has been investigated as a means of reducing, drying, and sintering shrinkage in the production of slip-cast fused silica radomes. Particle packing was increased to produce green bulk densities of greater than 2.0 gm/cm^3. Drying shrinkage was reduced to essentially zero and sintering shrinkage and properties were predictable and controllable.

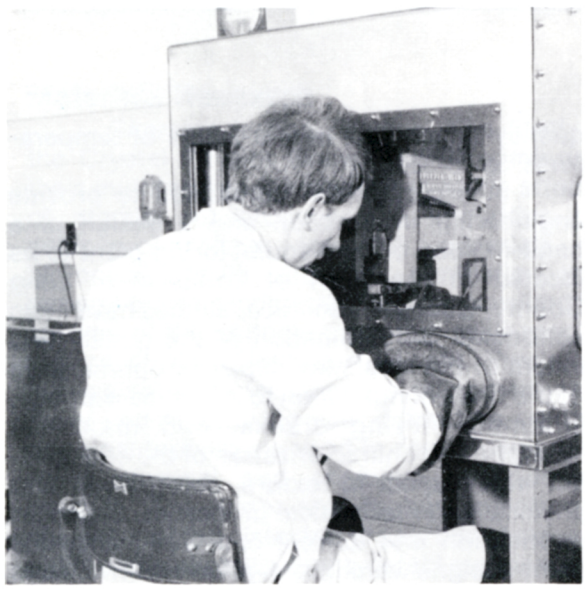
The feasibility of producing high-purity fused quartz by the mineral beneficiation of quartz sands with subsequent fusion of the sands to obtain an amorphous silica structure has been investigated for the U.S. Army Missile Command.

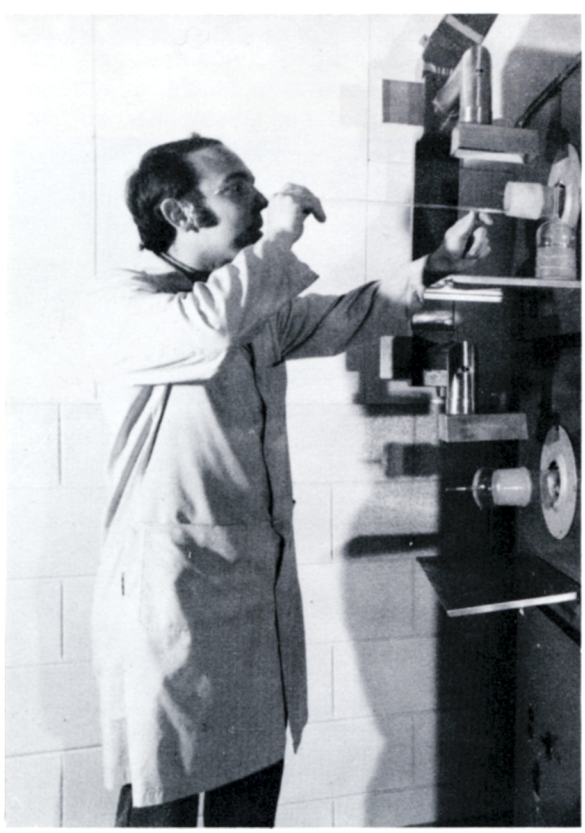
Studies to form reaction bonded silicon nitride radomes from slip-cast silicon have been conducted for the Naval Air Systems Command. The costs associated with fabricating slip-cast reaction sintered silicon nitride radomes in the laboratory were compared with the costs for slip-cast fused silica radomes. Radomes of two sizes were fabricated by pressure slip casting using a matched mandrel to define the inner surfaces. The techniques and materials to develop slips from silicon powder and to utilize pressure casting and reaction sintering procedures were developed. Transmission and pattern degradation measurements were made on the smaller radomes. Slip-cast reaction sintered nitride radomes could be formed with final nitrided densities of 2.0 to 2.6 gm/cm^3.

Microwave propagation tests (dielectric measurements) have been performed on various radome configurations in many frequency bands and over a range of temperatures up to 3000° F.

A program was conducted to provide engineering information and a design of a hand-molded brick manufacturing plant to be located in the town of Ludowici in Long County, Georgia. Technical studies have been conducted on verification of the quality and extent of the local clay deposits; optimization of the brick composition to minimize warpage, eliminate drying cracks, and maximize strength; and characterization of the end product with respect to texture, color range, and physical and mechanical properties. Based on information and current test work, alternate plant designs were investigated and two basic hand-molded plants capable of producing 6,600,000 standard bricks per year have been recommended.







Environmental and Life Sciences

A project sponsored by the Office of Water Research and Technology is being conducted to investigate the cause of trout kills in hatcheries where water is obtained from deep lakes. This project has identified manganese in lake water, observed during seasonal periods, even in small concentration, to cause fish kills in hatcheries located below dams. An unexpected result is that the addition of calcium in appropriate quantity to water containing manganese appears to be a corrective procedure to prevent fish kills.

The chlorination of water (particularly waste water) has been a subject studied during the year. The investigations have focused on the possible excessive chlorination of waste water such that through bacterial action the chlorine used for treatment is converted into compounds that are of biological concern (may end up in food chains that cause a harmful buildup of chlorine in living systems consuming the water).

A marijuana breath analyzer has been successfully demonstrated during the year. The sensitivity and operational aspects of this instrument utilizing gas chromatography are presently being explored.

During the current year investigations have been funded in the Micromechanics Laboratory under a small Biomedical Sciences Support Grant to study the environmental-mechanical behavior of elastin. Elastins are the "elastic" components in fibrous connective tissue in some ligaments and in the walls of larger blood vessels. The viscoelastic behavior of these biological materials were evaluated under various stress and strain conditions.

Systems and Techniques Department

Overview

The Department has continued to maintain strong and growing research programs during FY 1975. Financial support for the Department's operation is derived almost completely from sponsored operations, either through direct or indirect income. The major source of support is from individual agencies and/or offices of the Federal Government, with a variety of other support sources representing a smaller fraction of the total. The Department of Defense continues to be our largest sponsor, but our support from the National Aeronautics and Space Administration has continued to increase somewhat this year and we have several other sponsors among non-DoD federal agencies.

The goal of the Department is to grow steadily at 15 to 20 percent per year in performance of challenging research and development programs with an expanding support base. We will enter the new fiscal year in sound financial condition, with a funded backlog estimated to be about half again as large as last year, namely $2.1 million. In addition, funds of approximately $1.6 million have also been authorized for FY 1976 on existing contracts but, in accordance with Department of Defense procedures, have not yet been allocated. We thus will have the largest total backlog in our history, $3.7 million.

Research contracts with industry (including individuals and State of Georgia agencies) continue to be highly variable on a year-to-year basis. However, we continue to have a strong interest in increasing our interaction with industries, particularly those in Georgia.

Research Activities

Areas of sponsored activities within the Systems and Techniques Department include: antennas, radar systems, electromagnetic compatibility, radar reflectivity measurements and analysis, electromagnetic properties of materials, communications, radiolocation/direction finding, coherent optics, guidance and control, systems analysis, and biomedical electronics. The fundamental strength of this Department is in the performance of high-quality, client-oriented research by a competent and dedicated full-time technical and administrative staff. In addition to internal activities associated with preliminary research, industrial support, and growth programs, approximately 130 sponsored programs were active in the Department during the year, up from 115 the previous year. Brief mention can be made of only a few of our efforts.

Richard C. Johnson
Assistant Director for
Systems and Techniques

Communications Division

The Division continued its research activities in the areas of communications technology and electromagnetic compatibility. Digital communications remains as an active area of research including such investigative areas as bit-error-rate degradation in hard limiting transponders, allocation of implementation losses among subsystems, and analysis of offset phase-shift-keying. In a related area, the design for an on-board optical processor for spacecraft use is being developed.

In the area of RF systems, a special-purpose loop antenna is being designed for use on an Army helicopter. Based on extensive experience in direction-finding and radiolocation concepts, another research activity was concerned with radiolocation of radar emitters by a DF (direction finding) net. Electromagnetic characteristics of severe storms are being monitored using aircraft instrumentation developed for NASA.

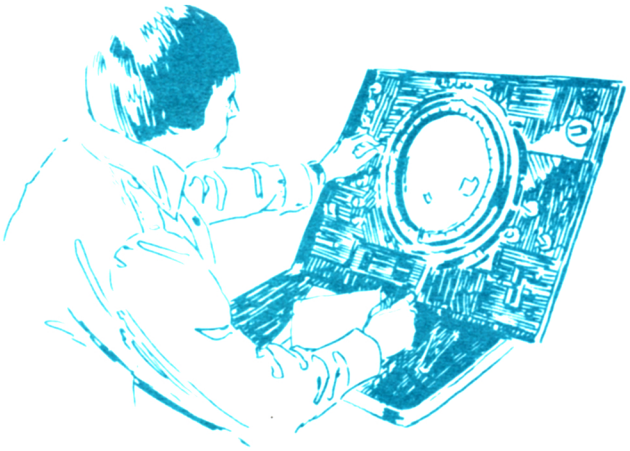
Electromagnetic compatibility activities during the year continued, as in the past, to be primarily concerned with the effects of electromagnetic environments on electronic systems. Major research efforts were directed to systems used in air traffic control and biomedical applications. National design and test standards to govern the electromagnetic performance of the complex electronic systems in airports and air route traffic control centers are under development for the Federal Aviation Administration. Research efforts concerned with electromagnetic performance evaluations of biomedical electronic devices reached new levels. Performance of cardiac pacemakers manufactured by U.S. and foreign firms was assessed under a wide variety of controlled electromagnetic environments.

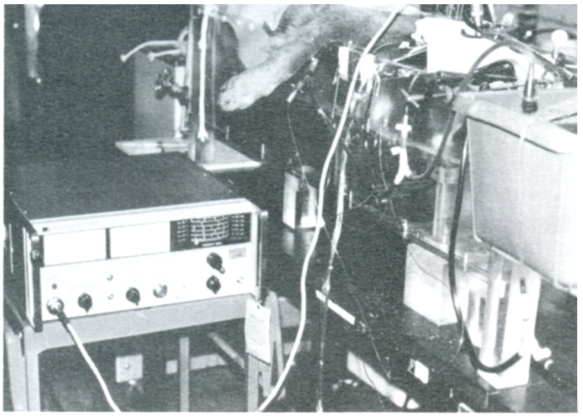
Radar Division

Major activities in radar, per se, have been in detection of target signatures, developing stationary target indication techniques, and in radar environment simulation. Four radar target discriminators were developed and currently are undergoing extensive flight test evaluations. The radar environment simulation work involves the development of a hybrid analog/digital, software/hardware system to accurately simulate coherent radar return from targets and clutter for injection into actual radar systems.

Although large support continues in the area of cost-effectiveness analyses of electronic countermeasures and radar systems, during the past year research activities have expanded into benefit-cost and engineering economics analysis of high-technology systems. Also, work continues in more general areas of systems analysis such as microwave tube reliability and manpower projection studies. These activities have resulted in the development of new analysis techniques. Characteristic of this area of research has been the use of multidisciplinary teams comprised of personnel from many units of Georgia Tech including Aerospace Engineering, Industrial Management, Industrial and Systems Engineering, and various Divisions of the Engineering Experiment Station.

Important research activities in electronic countermeasures technology ranged from the theoretical development and experimental evaluation of new techniques for use against operational radar systems to the feasibility determination of including special modes in non-ECM systems. In-depth analyses of an RF seeker have been performed to identify countermeasure susceptibilities and to determine where improvements can be made to enhance system performance. Considerable emphasis has been placed on assessing the performance of candidate projectile tracking radars.





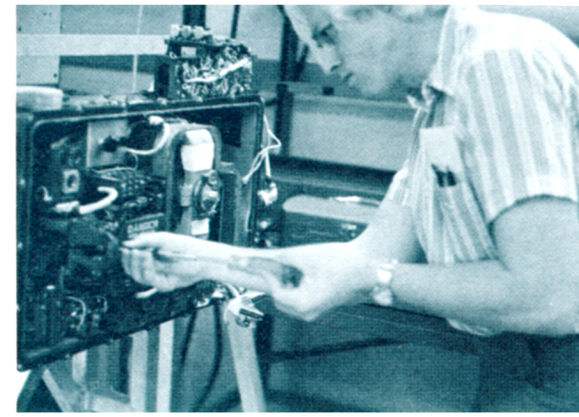
Work has continued on two long-term programs devoted to the development and practical exploitation of an innovative near-field technique for determining the microwave fields radiated by antennas or scattered by radar targets. Georgia Tech is one of the national leaders in development of this technique, which possesses several significant advantages over conventional measurement techniques, including the provision of information which cannot be obtained with conventional techniques. Work was initiated during the year to put this technique to practical use in assessing the performance of an advanced type of radar antenna. Also, one of our near-field facilities was used in assessing a new dispersal technique for conventional radar chaff.

In the area of technology assessment of devices and materials, a long-term program of technology assessment of active electronic devices has continued for the Naval Electronic Systems Command. This program is designed to provide the Navy with a continuing assessment which combines device and systems viewpoints so that technological barriers and research programs with a potential for high payoff can be identified. On another assessment project, measurements were made of the microwave absorbing properties of new materials which may have application as radar chaff.

Electromagnetic effectiveness research for the Navy has emphasized effective design and installation of microwave antennas and the impact of ship architecture on their performance. This research included analytical and experimental work on the effects of near-field blocking obstacles, out-of-band responses, main-beam distortion effects, and special electromagnetic compatibility problems associated with phased arrays. Support from the Air Force has been in analysis and development of measurement techniques for broadband microwave antennas and in the design of electrically small antennas. Army and NASA programs are for investigating the feasibility of near-field probing techniques for specific antenna measurement applications.

Sponsored research in the biomedical technical area has exhibited dramatic growth during this fiscal year. The research activities are built on background and experience in the interaction of electromagnetic fields with materials and on the design and development of electromagnetic illumination devices. The National Institute of Health sponsored one joint program between Georgia Tech and the Medical College of Georgia on freezing and thawing of kidneys to demonstrate the feasibility of cryopreservation, and another between us and the School of Medicine at Emory University to investigate the effectiveness of microwave thawing of human granulocytes that were frozen for preservation and storage. The National Science Foundation is sponsoring a program for investigating *in vivo* measurements of the electromagnetic properties of biological tissue. The Army Research Office in Durham has just initiated a program to develop energy absorption measurement methods for microwave heating of tissue.

Atlanta Journal Photo



Sensor Systems Division

Although the programs of the Sensor Systems Division are quite varied, most of them fall into one or more of six technical areas: radar systems analysis/development; radar antenna analysis/development; target detection in clutter; radar field measurement programs; radar cross-section prediction and control; and mechanical engineering and industrial support. Work ranges from theoretical analysis to equipment programs requiring design, development, fabrication, and testing of complete major systems. The greater part of the work this year has been under sponsorship of agencies of the Air Force, Navy, and Army.

The Division is continuing its long-term heavy involvement with the radar programs of the Naval Electronic Systems Command. One major effect is the development of a real time detectability analyzer (RTDA), and related prediction modeling. Major task areas include: design and fabrication of interfaces to ship's sensors, a video processor, and special field-support systems, along with performance of field operations. Dedicated minicomputers have been used very widely and their use has greatly expanded the Division's capability for handling complex analyses.

Radars for detecting projectiles and locating hostile weapons have been investigated in other continuing studies supported by ECOM, NAVELEX, DARPA, and USMC. Besides systems studies and trajectory and error analysis, these programs have included measurements of the radar cross-sections of projectiles. Other radar systems studies are concerned with swimmer detection by radar.

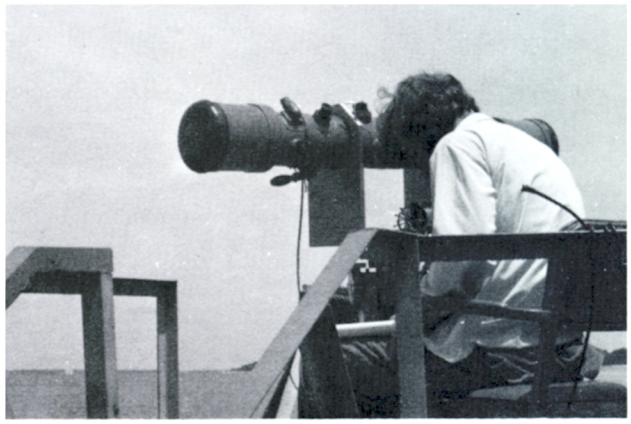
The analysis of tracking and command guidance radars is an area of radar systems studies in which the Sensor Systems Division has been a leader for some years. Work in this fiscal year has included detailed analysis of a specific system of interest to MICOM.

The Sensor Systems Division has acquired a national reputation in the design, development and fabrication of antennas. This fiscal year, the Division has performed approximately a dozen programs in this technical area. Antennas which have been or are being fabricated include a specialized Cassegrain type for a tracking radar, two C-band scanning paraboloids for another tracking system, an antenna for a seeker, and two very large back-to-back paraboloid sections with beam-shaping for a naval search system. Other antennas have included special lightweight designs and antennas for satellite use.

The Division is very active in performance of radar field measurements, both as a part of radar system development and for the purpose of acquiring basic data on the properties of land and sea clutter and of radar targets. A number of measurements have been performed this fiscal year, including work on land, sea and rain clutter at millimeter wavelengths. Specialized equipment includes a 95-GHz radar that can be used in the field and a mobile facility for on-site recording and analysis of data.

Prediction, measurement, and control of the radar cross-section of targets are involved in a number of the Division's programs. Work has included analytical and computer modeling studies, laboratory tests of techniques, and at-sea testing of equipment.

The Mechanical R&D Group within the Sensor Systems Division has continued to furnish extensive support to the mechanical engineering aspects of the Division's radar programs, particularly in the area of antenna design. It has also been conducting a program for the Army to develop techniques for realistically and safely simulating shell bursts and other phenomena of the battlefield for use in training. The Division is also monitoring under NSF sponsorship the installation and testing on the Tech campus of a personal transport system that was developed by a local industrial firm. Under sponsorship of the Georgia Department of Agriculture, it is performing continuing work on equipment for automating the handling of poultry in processing plants.

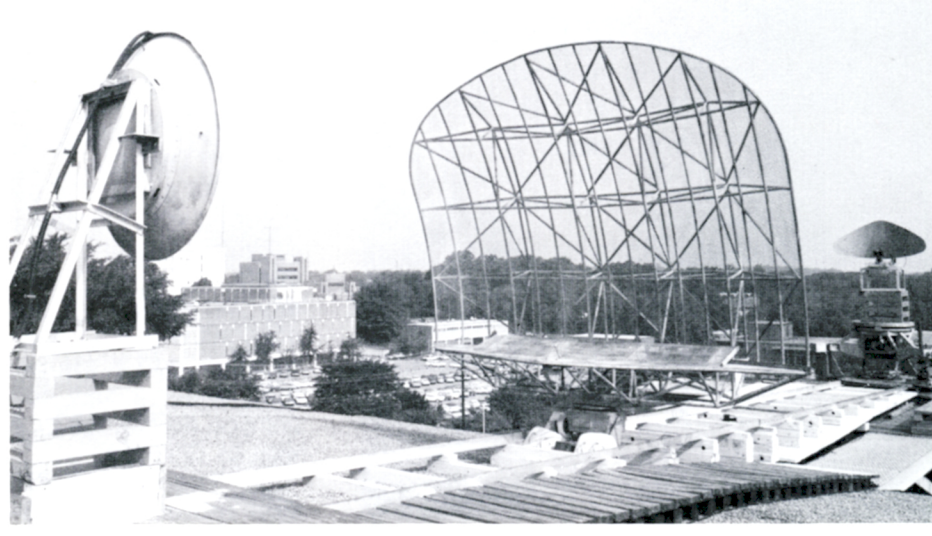


Special Techniques Division

Through active internal growth programs, the Special Techniques Division diversified its external support base with new programs involving testing and analysis of RF missile seeker systems, and studies of high-power submillimeter wave source applications. Investigation of optical and digital processing techniques for earth observation imagery was also continued under NASA sponsorship. An automatic optical-digital processing system was delivered, and a follow-on study of satellite-based optical processing systems was initiated. Millimeter wave radiometry was the subject of another NASA program which included development of advanced radiometers for measurement of atmospheric emissions relating to a study of severe weather. This multi-year program will result in high altitude flight tests from Guam in 1977, and will lead to observations from satellites. Still another program with NASA involved antenna designs for (and testing of) the SERT-C Satellite. Work with Martin-Marietta included a continuation of our long-time efforts on radomes.

Georgia-Related Research Activities

The Communications Division and the Radar Division have completed development of an experimental severe weather detection and tracking system. This system is presently undergoing test and evaluation in the Atlanta area. A medical bulletin describing pacemaker electromagnetic characteristics has been prepared by the Communications Division in collaboration with the Emory University School of Medicine and will be distributed to physicians throughout the State of Georgia. Related to this was a literature survey conducted to define electromagnetic environments hazardous to human health. Results from this effort, conducted in conjunction with the Department of Human Resources, will be used to survey potentially hazardous electromagnetic environments within Georgia. A program in the Sensor Systems Division is concerned with the difficult problem of transferring birds between poultry processing lines in order to be able to improve the automation of Georgia plants.



Industrial Development Division

Review of Research Activities

During a year when the national and Georgia economies were dominated by inflation, recession, and rising unemployment, the Industrial Development Division expanded its sponsored support and total volume of research and service activities. A total of 60 projects were undertaken for 49 different sponsors, including 39 Georgia-based agencies, institutions, communities, industries, and governmental units.

Thirty percent of the FY 1975 funding organizations were new sponsors. They included two State departments, five industrial or business concerns, five industrial development agencies, and three city governments, including one in Alabama. The renewal of contracts and grants from long-standing sponsors and this infusion of new sponsors helped IDD achieve the largest volume in the history of the Division and continued the growth trend exhibited in recent years.

The effect of the recession, however, was very noticeable in the state of Georgia in the economic development field. The number of industrial concerns interested in plant locations greatly decreased, and this impacted on IDD industrial contracts, resulting in fewer market analysis and plant location sponsored projects in fiscal year 1975. It is anticipated that there will be an increase in industrial contracts as the nation emerges from its depressed

Ross W. Hammond
Chief, Industrial
Development Division

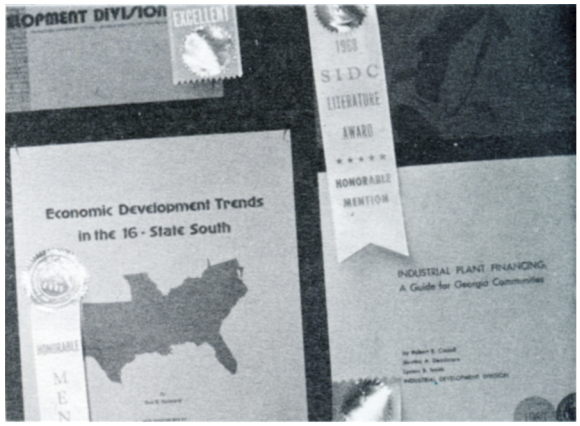
Despite this condition, a number of studies were supported by industrial organizations in FY 1975, including three projects for Georgia Power Company and a number of related programs for Armco Steel. In addition, technical assistance was provided to Coggins Granite Industries, and a number of minority business projects were conducted for Onyx Corporation and Urban East.

As in previous years, the sponsored income of the Division was generated from two primary sources: continuing sponsored projects and new sponsors. The bulk of the Division's activity is based on sponsors who continue to support the efforts year after year, and these "repeat customers" obviously are pleased with the services provided by IDD. Considerable attention was paid to developing new sponsors, both those who may become continuing supporters and those who require a one-time research, information, training, or service effort.

IDD's largest domestic and longest continuing sponsor, the Economic Development Administration (EDA), supported the widely acclaimed management and technical assistance program of the Division for the tenth consecutive year. EDA, which has been assured of at least three more years of existence by Congress, also is providing a grant to IDD in fiscal year 1976 to continue its provision of services to business and industry in depressed areas of Georgia.

As a result of the IDD activities under a contract with Farmers Home Administration to provide assistance to FHA and its loan applicants, the agency expanded its use of university assistance. In addition to extending its contract with IDD, the Mississippi R&D Center was included in the extension. It is anticipated that, under a new contract, the Division will provide assistance to Alabama and Florida as well as Georgia.

The Coastal Plains Regional Commission sponsored an 18-month housing assist-



ance program in which IDD provided the primary administration and guidance, working with a number of area planning and development commissions and local builders. The program has resulted in the construction of 1,500 low-cost housing units in the Coastal Plains region of Georgia, and it is estimated that another 1,500 units have been built utilizing the project's house plans.

The ongoing kaolin-to-alumina study, conducted under Coastal Plains Regional Commission funds provided through the Georgia Department of Community Development, continues to show promise of fuller development of this Georgia resource. The Bureau of Mines pilot plant process appears to be competitive with the bauxite-to-alumina process, and the major aluminum producers are following developments closely. This project could result in an entirely new major industry for Georgia, based on its natural resources and employing from 15,000 to 20,000 persons.

Two contracts during FY 1975 involved the Division in other states—Alabama and Montana. For the City of Tuskegee, a report was produced on the feasibility of establishing a National Cultural Center in Tuskegee. In Glasgow, Montana, with funds provided by the Old West Regional Commission, IDD initiated a series of community development leadership training programs involving local leaders and state industrial development personnel. In addition, as part of other contracts, activities were carried out in Florida and North Carolina.

The fastest growing activity in the Division in fiscal year 1975 was the international development activity for which Georgia Tech has achieved international recognition.

Six grants and contracts were received from the Agency for International Development, including continuation of the 211(d) grant to expand Georgia Tech's capabilities in small-industry development; administration of a small-industry grant contract in which direct grants are made to two institutions overseas; hosting of an international development conference/seminar in Atlanta, as well as a strategy symposium for AID's Office of Science and Technology; a basic ordering agreement for technical assistance on a task order basis; and the issuance of "Small Industry Development Network," a quarterly newsletter which goes to more than 1,000 readers in 80 countries and most of the United States to acquaint them with the activities of Georgia Tech and its counterparts. The 211(d) program involved personnel of other units of Georgia Tech, as well as Station personnel, in a program of information, education, and training with counterpart institutions in Ecuador, Brazil, Nigeria, Kenya, the Philippines, and Korea. Toward the end of the fiscal year, a seventh counterpart, the University of Science and Technology at Kumasi, Ghana, signed a formal counterpart agreement. Additionally, two contracts were obtained from Soong Jun University and the Fundacão Educacional do Sul de Santa Catarina for the provision of technical assistance to those organizations.

The field office contract support continued to expand through the addition of several municipal and county technical assistance contracts to the list of continuing projects.

The IDD staff responded to more than 1,900 requests for information, technical assistance, or problem solving during fiscal year 1975. Obviously, many of this large number of inquiries were quickly dealt with from available information sources or knowledge. Others took substantial staff efforts.

This activity was instrumental in several plant locations and industrial expansions, in proposal generation, in the preparation of industrial and manpower directories and research reports, in the provision of minority business assistance and housing assistance, and in providing information newsletters and services to Georgians, Georgia communities, and other units of government.

Opportunities and Plans for the Future

Higher Levels of Domestic Activity. The early concern about the growth of domestic activity in fiscal year 1976 has dissipated with assurance of continued EDA support in 1976 and beyond and the renewed interest in FHA in utilizing IDD support for its business and industry loan program. A new sponsor development team will continue to function to seek broadened support for domestic activities.

Higher Levels of International Activity. The continuing 211(d) grant and the proposed expansion of the small industry grant contract from $100,000 to $200,000 a year in fiscal year 1976 assure the base support necessary to build a substantial program in the international development field.

As fiscal 1975 terminated, eight different projects were being considered by AID which would utilize the Industrial Development Division. They include a two-year technical assistance project in the Philippines, a two-year field test of the Battelle Memorial Institute water pump, a three-year project to stimulate manufacture of International Rice Research Institute rice machinery in Thailand and Pakistan, and smaller projects in Ecuador, Ghana, Paraguay, and Uruguay.

A New Focus on Economic Development Training. With the new ground rules for Continuing Education programs and the perceived needs for economic development training by various agencies, some additional emphasis will be placed on this potential growth activity in the next several years.

Office of Program Development and Technology Applications Group

General Comments

The Office of Program Development directed its primary effort to the development and budgeting of programs aimed at producing accelerated growth in sponsored research at EES. Approximately 40 percent of the total General Research personal service funds available for the year were budgeted for growth programs.

The Technology Applications Group (TAG) maintained primary thrusts in waste utilization, industrial chemistry, minerals economics and beneficiation, and in industrial energy conservation. The overall growth in level of sponsored research that occurred is largely attributable to a steering of effort towards energy-related projects that fall into two categories: conservation technology and conversion of wastes into fuels.

Office of Program Development

The high priority for generating EES growth in sponsored research operations resulted in the investment of General Research funds in a number of important "growth" programs. In addition, some funds were invested in smaller amounts throughout EES to develop planning for subsequent year programs. Brief summaries of the major programs follow.

Solid State Materials and Devices

Objective: Increase sponsored research with an initial focus on needs perceived in the microwave semiconductor field.

Energy and Environment

Objective: Develop a thrust in energy and environment related to the chemical and material sciences; provide initial funding for a key person.

Solar Energy

Objective: Expand solar energy research and capabilities; provide initial funding for a key person.

Guidance and Sensor Technology

Objective: Develop a base of sponsored research in guidance and sensor technology using forefront techniques.

Infrared Technology

Objective: Develop a base of sponsored research in the applications of infrared technology.

Communications Systems

Objective: Develop a broadened base of sponsored research in communications systems technology.

Broaden Scope of Waste Utilization Laboratory

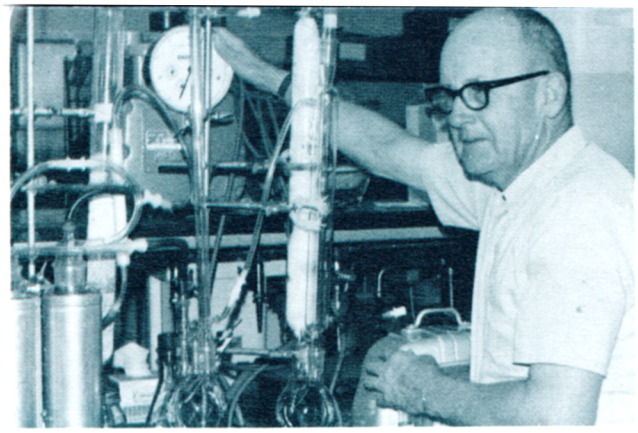
Objective: Develop an expanded base of sponsored research by extending the pyrolysis and other technologies into a broader spectrum of energy, fuels, and product applications.

Productivity Program

Objective: Develop a broad-based program to apply technology to increase industrial and governmental productivity in Georgia.

In addition to the foregoing major areas of thrust, most of which are expected to continue in the coming fiscal year, smaller projects were funded for growth planning in a number of new and existing areas. These areas include biomedical applications of electromagnetic radiation, meteorological technology related to radar and propagation, advanced microwave measurement techniques, radar and other electronic systems, and powder diffraction technology. [Wherever possible, specially qualified consultants were retained to assist in the planning efforts.]

Howard G. Dean, Jr.
Manager, Office of
Program Development



Technology Applications Group

Sponsored personal services during the year increased approximately 80 percent compared to the prior year. The outlook for the coming year is one of continued strong growth [unless there is an unavoidable inhibiting effect on the Waste Utilization Laboratory (WUL) in the administration of the license agreement for the waste converter and its related technologies.]

A significant portion of the growth was in energy-related work performed to aid Georgia business and industry in coping with energy problems. The work involved approximately 60 plant visits to establish energy profiles and to determine conservation potentials. State-wide management conferences and subsequent technical workshops were conducted to train and assist industrial representatives in Athens, Albany, Columbus, Macon, Brunswick, Savannah, Dalton and Gainesville, Georgia. This work, which was sponsored by the Economic Development Administration with cost-sharing by the State and EES, was described in testimony on April 18 at a U.S. Senate committee hearing on energy conservation at the request of Senator Sam Nunn. Additional energy-related work was performed for the Environmental Protection Agency by the WUL to develop portable systems using pyrolytic converter techniques for producing fuels. Other research to develop fuels from wastes was continued by the Industrial Chemistry Laboratory in its work to develop methane fuel gas from poultry waste for the Georgia Department of Agriculture.

Sponsored work in the WUL during the year included projects involving cotton gin wastes, poultry wastes, and extensive processing of municipal wastes. A 25-ton/day pilot plant was placed in operation and used to successfully process hundreds of tons of shredded municipal wastes. The potentials of the pyrolytic conversion of wastes were presented at a number of international, national and local conferences and meetings.

The Industrial Chemistry Laboratory continued its work with industrial clients on a variety of diversified contracts. In addition, late in the year it initiated work on a contract with the U.S. Department of Transportation for research on lane delineation on open-graded friction asphalt paving.

Minerals beneficiation and minerals economics work continued at approximately the same level as the previous year.

Technical Support

The Technical Support Department has the responsibility for accounting and fiscal matters, service operations, publications, space and physical property, internal management, the Office of Industrial Assistance and the Research Reactor. The Department continued its support and service operations for the research units of EES, but the year also saw a number of changes.

The Office of Industrial Assistance continued to provide response to inquiries for technical information and assistance. Approximately 150 such requests were handled during the year. However, principal interest in OIA centered on development of an EES-based productivity program for Georgia. Relations were strengthened with a number of trade associations, including the Carpet and Rug Institute, the S.E. Lumber Manufacturers Association, the Elberton Granite Association, the Poultry Federation and the Apparel Manufacturers Association. Assistance was furnished to Senator Nunn in preparing legislation for a National Productivity Center. Members of the EES staff, together with representatives from Georgia industry, presented testimony at the Senate hearings on this legislation December 16 and 17, 1974.

As a consequence of these efforts, Governor Busbee signed a resolution on April 8, 1975, which was passed by the General Assembly, designating EES as the Georgia Productivity Center. The resolution recognized the role of technology in efforts to improve the productivity of business and government, and the need for a designated group within State government to coordinate relevant federally funded programs. It further calls on EES to encourage productivity growth, perform research and development projects in conjunction with the National Commission on Productivity and Work Quality, and review productivity growth in the State to make appropriate recommendations for its improvement. It provides for an advisory council appointed by the Governor to provide guidance to the Productivity Center.

Sponsored research agreements were established, or were being negotiated, for projects in the areas of poultry, carpets, solar energy, gum naval stores, and local government services. Internally funded exploratory projects were conducted in such areas as industrial noise controls, energy conservation for carpet manufacturers, apparel waste utilization, silicon carbide recovery in the granite industry, and productivity methodology.

Operations of the Research Reactor resumed after a prolonged shutdown for conversion from a one- to five-megawatt capability. Both on- and off-campus use was at a relatively low level for the year which resulted in income from neutron sales being about one-third of that estimated.

Considerable attention was devoted to plans and arrangements for meeting EES's expanding space needs. Utilization of existing space is increasing rapidly and present growth trends indicate EES will face actual shortages of space in the near future. The pilot plant building in Area 2 was nearing completion as the year ended, providing some relief for the Waste Utilization Laboratory. During the year, work was also substantially completed on the facilities at the GTRI-owned field site in Cobb County.

Rudolph L. Yobs
Assistant Director for
Technical Support

Georgia Tech Research Institute

The majority of research performed at the Engineering Experiment Station is supported by contracts with governmental organizations and private industry. Contracts are based on prior negotiation and formal proposals and are normally established on a cost-reimbursement basis.

The Georgia Tech Research Institute serves as the contract agency for the EES and it handles patent matters in connection with research and development activities. The Research Institute is a non-profit organization incorporated under the laws of the State of Georgia. The Board of Trustees is composed of four members of the Georgia Tech faculty, four from Georgia Tech alumni and four from industry at large.

On June 30, 1975, members of the Board of Trustees included: James E. Boyd, Harllee Branch, Jr., Fuller E. Callaway, Jr., Vernon Crawford, Robert H. Ferst, Clyde W. Kennedy, III, Maurice W. Long, Joseph M. Pettit, Glen P. Robinson, Jr., Thomas E. Stelson, William B. Turner and Richard K. Whitehead, Sr. The officers of the corporation on that date were: Richard K. Whitehead, Sr., Chairman of the Board; Robert H. Ferst, Vice Chairman; Joseph M. Pettit, President; Thomas E. Stelson, Vice President for Research and Treasurer; Maurice W. Long, Secretary and Assistant Treasurer; Milton W. Bennett, Assistant Secretary and Assistant Treasurer, and Rudolph L. Yobs, Assistant Secretary.

Engineering Experiment Station Staff

The following listing reflects the current organization of the Engineering Experiment Station.

Thomas E. Stelson
Director (Acting)
Engineering Experiment Station
Telephone: 894-4825

Richard C. Johnson
Associate Director
Telephone: 894-3516

Howard G. Dean, Jr.
Associate Director, Programs and Services
Telephone: 894-3492

H. Allen Ecker
Director, Applied Engineering Laboratory
Telephone: 894-3523

Robert M. Goodman
Director, Systems and Techniques Laboratory
Telephone: 894-3507

J. W. Dees
Director, Electromagnetics Laboratory
Telephone: 894-3500

Douglas W. Robertson
Director, Electronics Technology Laboratory
Telephone: 894-3542

Gordon R. Harrison
Director, Applied Sciences Laboratory
Telephone: 894-3430

Ross W. Hammond
Director, Economic Development Laboratory
Telephone: 894-3800

Rudolph L. Yobs
Director, Productivity and Technology Applications Laboratory
Telephone: 894-3404

Monte V. Davis
Director, Nuclear Research Center Laboratory
Telephone: 894-3601

Readers with research and development problems are invited to contact the offices of the Engineering Experiment Station.

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